

SUPPLY RESPONSE OF ONION IN KARNATAKA STATE – AN ECONOMETRIC ANALYSIS

Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfillment of the requirement for the
Degree of

MASTER OF SCIENCE (Agriculture)

in

AGRICULTURAL ECONOMICS

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AUGUST, 2007

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1. INTRODUCTION

Agriculture is a major sector of the Indian economy, which provides employment for a large proportion of the predominantly rural population besides providing food for human consumption and raw materials for industries. The level and pace of development in the country have been and continue to be significantly influenced by the pace of its agricultural development. In India population has been growing at a very fast rate (from 361 million in 1951 to 1048 million in 2005). The national income of the country has increased from Rs.1,106.85 billion in 1980-81 to 13, 54.599 billion in 2004-05 (at current prices). Thus, the per capita income at current prices has risen from Rs.1, 630 (in 1980-81) to Rs.12, 416 (in 2004-05) per annum. The agricultural production in the country has increased at the rate of 2.67 per cent per annum during the period 1949-50 to 19 per cent during 2006-07 (Anon., 2006). The rapid growth of population accompanied by rising levels of income resulted in a rising demand for agricultural products. Such a situation necessitates a fairly high rate of growth in agricultural sector to meet the demand for agricultural products in the country. To achieve this, an efficient utilization of resources is necessary. The farmers' decisions regarding resource allocation are influenced mainly by the government. Hence, formulation and speedy implementation of policies which will induce a substantial expansion of agricultural production becomes imperative.

The question regarding the growth of supply has two equally important aspects. The first aspect refers to the growth of agricultural products, which includes even the development of new resources for agriculture and improving the technological and institutional frame leading to shifts in the supply function. The second aspect deals with the supply response of agricultural products to the changing levels of prices.

Price is the most important determinant of profit or loss in the farm enterprise. When market price is behaviour in relation to cost, it leads to profit and provides incentive to producers to grow more. Hence the short-run changes in prices and their effect on production behaviour have been receiving a great deal of attention. A more effective formulation of agricultural policy is needed for developing economy where a systematically planned and rationally phased development is being attempted. Hence, in order to bring about sustained and balanced economic growth, it is very important to understand the long-run effect of prices on production. That is why the role played by the government by way of price fixation and market operations must be based on the knowledge of how precisely the producers respond to prices. This would be in balancing the demand for and supply of a given commodity. On the whole, an appropriate price policy is crucial for the growth and stability of production.

However, a favorable price policy alone may not induce the farmers to increase agricultural output in order to attain the desired targets. In addition to price incentives, non-price incentives like provision of assured irrigation and high yielding variety seeds with package of practices are equally important which help to increase yields in achieving the output targets. Some times the response behaviour of farmers may be influenced more by the non-price variables than the price variable. This was observed in some studies in the past (H.Basavaraja, 1982, Mahajanashetti, *et al.*, 1990, Sarup and Pandey, 1990, Sadasivam, 1993, Patel and Singh, 1994, Bhowmick and Goswami, 1998 and Dixit, *et al.*, 1998). Hence the study of farmers' supply response to price and non-price incentives is of paramount importance for devising suitable agricultural policies and planning suitable programme(s) for agricultural development of any economy, particularly in those countries where agriculture is by and large the most important sector in the national economy.

The response behaviour of farmers is a much-debated issue and there appears hardly any agreement over the nature and magnitude of response of agricultural supply in a subsistence farm economy characterized by traditional inputs. One of the two important hypotheses on this controversial issue is that there is little or even inverse relationship between the changes in price and output in subsistence agriculture. The prominent protagonists of this hypothesis are Nemark (1959), Olson (1960), Mathur and Ezekiel (1961), Krishnan (1965), and others. The other hypothesis advanced is that the supply of farm commodities in under-developed countries shows not only quick but also positive response to price changes. The important advocates of this hypothesis are Rajkrishna (1963), Jaikrishna (1965), Schultz (1965) and others.

There seems to be no consonance among the researchers with regard to the response variable too. While most of the researchers have resorted to acreage response to represent supply response, some have regarded yield as a correct response variable and very few have considered both area and yield responses in their studies. There exists a difference of opinion even regarding the specification of price factor and the selection of non-price variables in supply response investigations.

The present study on supply response of onion in Karnataka state is an attempt to examine whether the production decisions of onion growers in the State have any relevance to changes in prices and selected non-price variables.

1.1 Importance of Onion in the Economy

Onion is one of the most important commercial vegetable crops grown in India. Among the bulb crops onion is the only member grown to a great extent in this country. It is one of the versatile vegetable crops belongs to the family Amarillidaceae. It is used both in immature and mature bulb stages as a vegetable and as a spice. It contains vitamin 'B', traces of vitamin 'C', carbohydrates, protein and traces of minerals like iron, calcium and phosphorus. The outstanding characteristic of onion is its pungency, this is due to a volatile oil known as allyl-prophylsulfide. The pungency varies with variety, growing conditions, stage of maturity, type of soil, soil temperature and storage conditions. It is maximum just before fall of top in the field. The outer skin colour is due to the presence of quereetin.

Karnataka State, being one of the major onion producing States in the country had 115.2 thousand hectares under onion with total production of 724.5 thousand metric tones in the year 2005. The State ranks fourth in terms of onion productivity in India with an average productivity of 3,272 kilograms per hectare. (Source: Agriculture, CMIE report April, 2007)

1.2 The present study

The present study aims at examining the response behaviour of onion growers to the changes in price and selected non price variables in Karnataka state in general and seven important onion growing districts in particular. Separate area, yield and production response functions will be estimated for each selected district and the state as a whole to evaluate the responsiveness of onion growing farmers to changes in prices and non-price factors. This will be estimated by the application of Nerlovian price expectation-cum-area adjustment model.

1.3 Objectives of the study

The overall objective of the present study was to know how the farmers respond to changes in price and selected non-price factors of onion in the Karnataka state.

The specific objectives of the study were

1. To document the growth in area, production and Productivity of onion in Karnataka.
2. To evaluate the impact of relative price and selected non-price factors on the supply of onion in Karnataka state.
3. To analyse the short and long-run price elasticities of supply of onion in the State.
4. To suggest appropriate policy measures for improvement of onion production in Karnataka state.

1.4 Hypotheses

The hypotheses of the study are

1. There is an increase in area, production and Productivity of onion in Karnataka
2. Farmers respond favorably to changes in both price and non-price factors in onion production in Karnataka state.
3. The supply of onion in the State is inelastic both in short and long-run.

Table 1.1 Area, production and productivity of onion in the major producing states of India (2005)

State		Area ('000 ha)	Production ('000 MT)	Productivity (kg/ha)
1.	Maharashtra	121.7 (20.5)	1,422.3 (18.9)	11,687.0
2.	Karnataka	115.2 (19.4)	724.5 (9.6)	6,290.6
3.	Gujarat	58.5 (9.9)	1,340.6	22,916.0
4.	Orissa	55.5 (9.3)	488.0 (7.5)	8,792.0
5.	Rajasthan	42.9 (13.5)	347.9 (7.6)	1,123
	All India	539.9	7515.4	12,654.0

Note: Figures in parentheses indicate percentage to the all India figure.
Source: Agriculture, Centre for Monitoring Indian Economy (CMIE).

1.5 Limitation of the study

Because of constraints of time, resource and man power of researcher present study is confined only to three major onion growing districts of the state. Study was conducted according to old classification of districts of the state, because of non availability of necessary data of newly formed districts for recent ten years.

1.6 Presentation of the study

The study is presented in six chapters. The first chapter is devoted to a broad analysis of the problem and specification of the objectives. The second chapter presents the review of some of the earlier studies related to the present study. Chapter three describes the general features of the study area, specification of variables used in the study and the analytical frame work. The results obtained from the study are presented in the fourth chapter and the discussion of results in the fifth chapter. In the final chapter a summary of the main findings and the policy options that could be adopted are presented.

2. REVIEW OF LITERATURE

Since past there have been quite a number of empirical studies on supply response and economic rationale of farmers in both developed and developing agricultural economies. However, the nature and extent to which farmers respond to changes in price and non-price factors still remains a controversial issue. Some of these studies deal with methodological aspects, while others are related to estimation of supply parameters of specific crops. A review of such studies is presented in this chapter, with a view to provide necessary foundation for building up both conceptual and operational supply response models for an in depth analysis of onion crop in Karnataka State.

The review of the study is presented under the following heads.

2.1 Growth rate analysis

2.2 Methodology and Econometric Models used in the Supply Response Analysis

2.3 Response Variables – Area and Yield

2.4 Price Factor

2.5 Supply Shifters (Non-price factors)

2.1 Growth rate analysis

There has been a considerable addition to the literature on the growth of agricultural output in our country after the introduction of green revolution in the latter half of the 1960's. Some of them have been reviewed here.

Nair *et al* (1982) estimated the trends in respect of area, production and productivity of coconut in Kerala across districts during the sixties and seventies. Area under coconut was found to be rapidly expanding during the sixties and the first half of the seventies. However, the production of nuts started declining by early 1970s. By comparing the yield performance over the period of Alappuzha district, situated at the heart of the coconut root (wilt) disease belt and other districts, he repudiated the oft-repeated villainous portrayal of the root (wilt) disease in the coconut economy of the state.

Naik and Patnaik (1984): calculated the compound growth rates of area, output and productivity of potato in Orissa during the period 1971 to 1981. The growth rates of area (3.5 percent), output (3.08 percent) and prices (0.05 percent) were found statistically significant but not that of productivity (-0.0049 per cent per annum).

Yeledhalli (1987) computed the growth rates of area, production and productivities of dry chillies in Dharwad district by using the compound growth rate of the type $Y_t = AB^t$. The growth rate in area (6.73 %) was found to be greater compared to the growth rates of production (3.42 %) and productivity (0.14 %). The growth in production was the combined effect of the growths in both area and productivity.

Raju and Luckose (1991) analyzed the trends in production and yield per acre for chillies in India during the period 1951-52 to 1987-88. During this period area under cultivation, production and productivity of chilli increased. The area increased from 540 thousand hectares in 1951-52 to 814 thousand hectares in 1986-87. For the same period, production increased from 347 thousand tonnes to 780 thousand tonnes and yield per hectare from 620 kg to 958 kg.

Krishnan *et al.* (1991) worked out trends in growth rates of area, production and productivity of major crops in Kerala for the period 1970-71 to 1986-87 and compared them with the corresponding trends at the all-India level. Negative growth rates of output were registered by four out of the ten crops studied viz., rice, tapioca, areca nut and coconut. Growth rates of production were positive and significant for only two crops namely, dry ginger and rubber. Negative and significant growth rates of area of rice and tapioca indicated a shift in cropping pattern in favour of cash crops or plantation crops.

Bhowmick and Ahmed (1993) examined the growths in area, production and yield of major oilseed crops in Assam during the pre and post green revolution periods. Linear trends and compound growth rates of area, production and productivity of oilseed crops were worked out by fitting linear function of the type $Y = a + bt$ and exponential function of the type $Y = AB^t$. During the period from 1950-51 to 1988-89, rapeseed and mustard registered 3.34 per cent growth in production which was result of 2.96 per cent and 0.35 per cent growth in area and productivity of the crop respectively. The results indicated that increase in oilseed production had been related to increased acreage rather than intensification of production.

Patil (1995) estimated the compound growth rates of area, production and productivity of groundnut in Dharwad district and at the State level for the period from 1984-85 to 1993-94 and identified that the growth rate in area (0.51 %) was positive but not significant as compared to the significant growth rates in production (6.89 %) and productivity (6.34 %). During the same period growth rates in area (5.24 %), production (10 %) and productivity (4.63 %) of groundnut for the State as a whole were positive and significant.

Guledgudda *et al* (2001) analysed the trend in area, production and productivity of tea production in India from 1973-74 to 1997-98. The results revealed that the growth in area, production and productivity over the years were positive but negligible. Both area and productivity partially contributed towards positive growth in production.

Pervez (2001) analyzed the growth in area, production and yield in the major crops of Pakistan for a period 1970-71 (period I) to 1984-85 (period II). The study revealed that the increase in crop production was contributed largely by area than by productivity in Punjab and Sindhu during period I. Sindhu region recorded a higher growth in area, production and yield as compared to Punjab in period II. It was also observed that Punjab recorded a low degree of instability in growth rates in most of the crops as compared to Sindhu region in period II.

Varghese (2004) worked out the trend in area, production and productivity of cardamom in Kerala for a period from 1970-71 to 2002-03 using semi-logarithmic growth equation. The area under cardamom registered a negative growth rate (-1.216%) which was significant. The output grows at an average annual trend growth rate of 4.14 per cent and yield registered an average annual growth rate of 5.51 per cent.

Lathika and Kumar (2005) analyzed the growth trends in area, production and productivity of coconut for different coconut producing states/union territories in India. The period has been divided into two sub-periods as phase I (1951 to 1995) and phase II (1996 to 2002). Area shows positive growth in both phases for selected states except for the Andaman and Nicobar islands where the growth was negative (-9.69) in II phase. Production also showed a positive growth in all the states in both the phases and Andhra Pradesh has highest growth in II phase (16.69%). The growth rate of productivity shows negative growth in Kerala and Orissa in the I phase, Karnataka in the II phase.

2.2 Methodology and econometric models used in the supply response analysis

The procedures and analytical techniques used in the supply response studies by different investigators are reviewed under this head.

Rajagopalan (1967) tested the following three variants of the basic Nerlovian supply hypothesis:

$$A_t = Q_0 + a_1 A_{t-1} + a_2 A_{t-2} + a_3 P_{t-1}^R + a_4 T + u_t \text{-----(2.10)}$$

$$A_t = b_0 + b_1 A_{t-1} + b_2 P_{t-1}^R + b_3 T + u_t \text{-----(2.11)}$$

$$A_t = c_0 + c_1 A_{t-1} + c_2 Y_{t-1} + c_3 P_{t-1} + c_4 P_{t-1}^S + c_5 T + u_t \text{-----(2.12)}$$

Where,

A_t = The total acreage under the crop,

P_{t-1} = The lagged absolute price of the crop,

- P_{t-1}^R = The lagged relative crop price,
- P_{t-1}^S = The lagged substitute crop price,
- Y_{t-1} = The lagged crop yield, and
- T = The trend.

The hypothesis that underlies equation (2.12) is that the adjustment process was of different form and received little supporting evidence in regressions undertaken, particularly in the case of subsistence crops. The results Rajagopalan obtained from estimating the parameters of equation (2.10) and (2.11) which differs from one another in the use of relative versus absolute prices of the reference crop and the substitute crops, showed generally better results when the absolute prices in equation (2.12) were used.

Cummings (1975) in his study of the supply responsiveness of Indian farmers in the post-independence period, with respect to major cereals and cash crops, used the model, which was completed by Nerlove's formulations of price expectation and area adjustment. The model was specified as follows:

$$A_t^D = a_0 + a_1 P_t^* + a_2 R_t^* + a_3 T + U_t \dots \dots \dots (2.13)$$

$$P_t^* - P_{t-1}^* = b (P_{t-1} - P_{t-1}^*) \dots \dots \dots (2.14)$$

$$A_t - A_{t-1} = c (A_t^D - A_{t-1}) \dots \dots \dots (2.15)$$

Where,

- A_t^D = the desired acreage of the crop,
- P_t^* = the expected realized price,
- R_t^* = the anticipated water availability
- T = the trend variable and A_t and P_t are the actual acreage and price respectively.

By substituting equations (2.14) and (2.15) in (2.13) and by manipulating equation (2.13) algebraically, the following equation susceptible to analysis resulted:

$$A_t - (1-b)A_{t-1} = a_0bc + a_1bcP_{t-1} + (1-c)[A_{t-1} - (1-b)A_{t-2}] + a_2c[R_t - (1-b)R_{t-1}] + a_3c[T - (1-b)(T-1)] + c[U_t - (1-b)U_{t-1}] \dots \dots \dots (2.15)$$

The problem of parameters identification was avoided by separately estimating equation (2.14) for a range of specified values of b, the price expectation coefficient, which could be reasonably assumed to fall within the range of zero to two. The best of the resulting sets of estimates was then chosen on the criterion of minimum error sum of squares. The problem of auto-correlation was encountered because of the presence of lagged values of the dependent variable. An Ordinary Least Squares method was used to estimate the parameters of the model.

Sawant (1978) analyzed the supply response of paddy in 16 districts of India. To avoid the problem of aggregation, she selected only those districts in which paddy dominated (more than 70 per cent of the gross area). She incorporated Nerlovian partial adjustment model in her formulation.

$$Y_t^* = A + aP_t^* + U_t \dots \dots \dots (2.17)$$

$$P_t^* = P_{t-1} \dots \dots \dots (2.18)$$

$$Y_t - Y_{t-1} = \gamma(Y_t^* - Y_{t-1}) + bI_t + cW_t + V_t \dots \dots \dots (2.19)$$

Where,

- Y_t^* = the desired area (or yield per acre) of paddy,

Y_t = the actual area (or yield per acre) of paddy,

P_t^* = the expected real price of paddy,

P_t = the actual real price of paddy,

I_t = the irrigated area under paddy, and

W_t = the rainfall in different months or periods.

The reduced form of the equation obtained was:

$$Y_t = a_0\gamma + (1-\gamma) Y_{t-1} + a_1\gamma P_{t-1} + b_1I_t + a_2W_t + \gamma U_t + V_t \dots (2.20)$$

She used Ordinary Least Square (OLS) technique to estimate the parameters of the equation (2.20). She derived price elasticities of acreage and yield per acre and obtained the elasticity of supply (production) by adding the two.

Lal and Singh (1981) examined the impact of relative sugarcane profitability, risk and other non-price factors on the acreage allocation behaviour of sugarcane farmers in Uttar Pradesh. On the basis of the Nerlovian model, they developed an adjustment lag model and analysed the response relationship with the help of the following equation.

$$\text{Log ACRS}_t = \text{Log } a + b_1 \text{ log ACRS}_{t-1} + b_2 \text{ log RSPF}_{t-1} + b_3 \text{ log PRSK} + b_4 \text{ log RNPS}_{t-1} + b_5 \text{ log AIDP}_{t-1} + b_6 \text{ log TIMT} + \text{log } U_t \dots (2.21)$$

where,

ACRS_t = area under sugarcane in period t ,

ACRS_{t-1} = area under sugarcane in period $t-1$,

RSPF_{t-1} = gross relative sugarcane profitability lagged one year,

PRSK = price risk,

RNPS_t = rainfall during pre-sowing month,

AIDP_{t-1} = area infested with diseases and pests lagged one year,

TIMT = time trend, and

U_t = random error term.

Baltas (1987) in the study on supply response for Greek cereals using Nerlove's traditional model, calculated price elasticities suggest that Greek farmers are reasonably responsive to price changes, though the degree of responsiveness varies considerably from product to product. Some policy implications are drawn from the analysis, given EC and national cereal price policies.

Ramesha. *et al* (1988) in the study Supply response of rice in Karnataka, estimated the supply response of rice to price in Karnataka, India, showed that there was a positive supply response to price incentives in developing countries. The magnitude varies according to the nature of the crop and between regions, so regional studies are useful when formulating national policies. Separate area and yield response models are estimated using a Nerlovian lagged adjustment model, for the period 1960/61 to 1984/85. Yield found to be responsive to price, but area less so as cropping patterns tended to be more or less established.

Murthy *et al.* (1992) in their analysis of supply response of turmeric in Guntur district of Andhra Pradesh, developed the following area and yield models separately on the basis of Nerlovian adjustment lag model:

1. Area response model:

$$A_t = b_0 + b_1 A_{t-1} + b_2 P_{t-1} + b_3 R_t + U_t \dots (2.22)$$

or

$$A_t = b_0 A_{t-1} \cdot P_{t-1}^{b_1} \cdot R_t^{b_2} \cdot U_t^{b_3} \dots \dots \dots (2.23)$$

2. Yield response model

$$Y_t = a_0 + a_1 Y_{t-1} + a_2 P_{t-1} + a_3 R_t + U_t \dots \dots (2.24)$$

or

$$Y_t = a_0 Y_{t-1} \cdot P_{t-1}^{a_1} \cdot R_t^{a_2} \cdot U_t^{a_3} \dots \dots \dots (2.25)$$

Where,

A_t and A_{t-1} = acreage under turmeric in i^{th} and $(t-1)^{th}$ year respectively,

P_{t-1} = average wholesale price in $(t-1)^{th}$ year,

R_t = Price risk,

Y_t and Y_{t-1} = Yield of turmeric in i^{th} and $(t-1)^{th}$ year respectively, and

U_t = error term

Between the two functions, viz., the Multiple Linear Regression and the Cobb-Douglas type function developed in each model, the best fit was selected based on the value of R^2 and significance of regression coefficients.

An expected utility model that includes output price and yield uncertainty was used to estimate cotton, maize and soybean acreage response equations for South-Eastern USA using time series data for 1955-88 by Duffy *et al.* (1994). The model appeared to fit the soybean and maize data well, resulting in own-price elasticity estimates of 0.317 for maize and 0.727 for soybeans. When applied to cotton acreage, however, the model did not yield satisfactory results. The results indicated that risk variability of soybeans appeared to affect acreage of soybeans and maize and possibly cotton, but that price variability in maize and cotton has little effect on planting decisions due to the extensive farm programme provisions for maize and cotton.

Cauvery (1993) analysed the impact of price change on acreage under Groundnut in south arcot (Tamil Nadu) by making use of multiple linear regression through Nerlove's model of the form $(A_t - A_{t-1}) = \gamma(A_{t-1}^* - A_{t-1})$, $0 < \gamma < 1$, Where, A_t^* is the planned acreage under the crop, A_{t-1} is actual acreage under the crop in the year $t-1$, a and b are constants and γ is coefficient of adjustment. The estimated model included acreage as a proxy for supply and lagged acreage, yield rainfall, time trend and wholesale prices as independent variables. The value for the coefficients of a multiple determination indicated a significant response of ground nut acreage in relation to the three months pre-sowing average price in current year. Its short-run (0.207) and long-run elasticities (less than one) revealed that farmer's were not more responsive to price changes in the case of cash crops like groundnut.

Deshpande (1994) used Nerlovian Price Expectation-cum-Area Adjustment Model for better results in estimating the area, yield and production response functions of chilli in Karnataka State with the help of single equation Models. The reduced forms of the models used are as under:

Area Response Function:

$$A_t^* = b_0 + b_1 P_{t-1} + b_2 A_{t-1}^* + b_3 Y_t^* + b_4 W_{t-1}^* + b_5 I_t^* + b_6 R_t^* + b_7 T_t^* + e_{1t}^* \dots \dots (2.26)$$

$$A_t^* = b_0 \cdot P_{t-1}^{b_1} \cdot A_{t-1}^{b_2} \cdot Y_t^{b_3} \cdot W_{t-1}^{b_4} \cdot I_t^{b_5} \cdot R_t^{b_6} \cdot T_t^{b_7} \cdot e_{1t}^* \dots (2.27)$$

Yield Response Function:

$$Y_t^* = b_0 + b_1 P_{t-1} + b_2 Y_{t-1}^* + b_3 W_t^* + b_4 I_t^* + b_5 R_t^* + b_6 T_t^* + e_{2t}^* \dots \dots \dots (2.28)$$

$$Y_t^* = b_0 \cdot P_{t-1}^{b_1} \cdot Y_{t-1}^{b_2} \cdot W_t^{b_3} \cdot I_t^{b_4} \cdot R_t^{b_5} \cdot T_t^{b_6} \cdot e_{2t}^* \dots \dots \dots (2.29)$$

Production Response Function:

$$Q_t^* = b_0 + b_1 P_{t-1} + b_2 Q_{t-1}^* + b_3 W_{2t}^* + b_4 Y_t^* + b_5 R_t^* + b_6 T_t^* + e_{3t}^* \dots \dots \dots (2.30)$$

$$Q_t^* = b_0 \cdot P_{t-1}^{b1} \cdot Q_{t-1}^{b2} \cdot W_{2t}^{b3} \cdot Y_t^{b4} \cdot R_t^{b5} \cdot T_t^{b6} \cdot e_{3t}^* \dots \dots \dots (2.31)$$

Where,

- $A_t^* = A_t - (1-\beta)A_{t-1}$ = the desired area in period t,
- $A_{t-1}^* = A_{t-1} - (1-\beta)A_{t-2}$ = the desired area in period t-1,
- $Y_t^* = Y_t - (1-\beta)Y_{t-1}$ = the yield variable,
- $W_{1t}^* = W_{1t} - (1-\beta)W_{1t-1}$ = the rainfall variable,
- $R_t^* = R_t - (1-\beta)R_{t-1}$ = the relative return risk variable,
- $I_t^* = I_t - (1-\beta)I_{t-1}$ = the irrigation variable,
- $T_t^* = T_t - (1-\beta)T_{t-1}$ = the trend variable,
- $e_{it}^* = e_{it} - (1-\beta) e_{it-1}$ = the random error term (i=1,2,3),
- P_{t-1} = the relative price in period t-1,
- A_t = the actual area in period t,
- $Y_{t-1}^* = Y_{t-1} - (1-\beta)Y_{t-2}$ = the desired yield in period t-1,
- $W_{2t}^* = W_{2t} - (1-\beta)W_{2t-1}$ = the rainfall deviation,
- $Q_t^* = Q_t - (1-\beta)Q_{t-1}$ = the desired production in period t,
- $Q_{t-1}^* = Q_{t-1} - (1-\beta)Q_{t-2}$ = the desired production in period t-1,
- β = the coefficient of expectation, and
- b_i = regression coefficient (i=1,2,3. . .)

The error correction model which avoids the familiar partial adjustment model's unrealistic assumption of a fixed target supply based on stationary expectation is employed by Abdulai and Rieder (1995) to investigate the impacts of agricultural price policy on cocoa supply in Ghana. The model provided good empirical results and is preferred in specification tests to the partial adjustment model. The results revealed that cocoa supply is significantly influenced by the real producer price of cocoa, real price of maize, the supply of manufactured foods and the real exchange rate. The supply of cocoa was found to be inelastic both in short and long run. However, the elasticities obtained in the study suggested that supply of cocoa is more responsive in a shorter time than thought previously.

Reddy and Chengappa (1995) used the normalized quadratic form of profit function approach to derive output supply elasticities with respect to output and input price for major cereals in Karnataka, India. The data pertaining to 100 rice farmers, 71 sorghum farmers and 62 millet farmers were collected for the period 1982/83-1985/86. The scope of increasing output of sorghum, rice and millet by means of produce and input price adjustments was found to be limited. Thus, it was suggested that, there is a need for technological improvement in these crops in order to achieve production targets.

Gafar (1997) utilized the Nerlovian adjustment model in studying of supply response of aggregate agricultural output in Jamaica for the period 1964 to 1990. He assumed that the desired output (Q^*) is given by the following long run relationship.

$$\ln Q_t^* = a + b \ln P_{t-1} \dots \dots \dots (2.32)$$

Where,

P = Price, t = time, and \ln = the natural log

Further he assumed that the actual agricultural output (Q) doesn't immediately move to Q* as P changes, but it responds by the following process:

$$\ln Q_t - \ln Q_{t-1} = \lambda (\ln Q_t^* - \ln Q_{t-1}) \dots (2.33)$$

Where,

$0 \leq \lambda \leq 1$, is the speed of adjustment

Substituting equation (2.33) in equation (2.32) and adding a time trend (t) to account for such effects as advances in agro-technology and an error term (u) got the estimating equation as:

$$\ln Q_t = A_0 + A_1 \ln P_{t-1} + A_2 \ln Q_{t-1} + A_3 t + U_t \dots (2.34)$$

Where,

$A_0 = \lambda_0$, $A_1 = \lambda b$, $A_2 = 1 - \lambda$ and U_t is assumed to follow

$$U_t = \rho U_{t-1} + e_t$$

such that $|\rho| < 1$: $E(e) = 0$; $Cov(e) = \sigma^2 I$

Kumar and Rosegrant (1997) in their study of Dynamic Supply Response of Cereals and Supply Projections, have derived a model from a multinomial logistic function for area allocation which determines shares of total crop area allocated to each crop as a function of expected crop revenues per hectare and quasi-fixed inputs. The linear version of multinomial logit model for area allocation is given by:

$$\ln (w_i/w^*) = a_i + \sum b_{ij} \ln(r_j) + \sum c_{il} \ln(A_l) + U_i \dots (2.35)$$

Where,

$$\ln (w^*) = \sum \bar{w}_i \ln (w_i),$$

w_i = the individual crop shares,

\bar{w}_i = the average area share of i^{th} crop,

w^* = is the weighted geometric mean of the crop area shares,

γ_j = the j^{th} expected net crop revenue, and

A_l = the l^{th} type of total land in the crop system (total irrigated area and total rainfall area).

The transformed shares of total area allocated to each of the crops area thus estimated as a function of the normalized net crop revenues per hectare of each of the crops and total irrigated and total rainfed area respectively for all crops.

However, being extremely simple but effective means of adding a dynamic response in an allocation model, the restricted dynamic linear logit model of the following form was used for area allocation.

$$\ln(w_i/w^*)_t = a_i + \gamma_i \ln(w_i/w^*)_{t-1} + \sum b_{ij} \ln \gamma_j + \sum c_{il} \ln A_l + u_i \dots (2.36)$$

The adjustment coefficient across equations (γ_i) area tested and restricted to be equal. The equilibrium values of the estimated coefficients are obtained by dividing each coefficient by $(1 - \gamma_i)$.

Erjavec and Turk (1997) evaluated the supply response and structural breaks in Slovene agriculture over the 1966-1996 period. The Karman filter procedure was applied in deriving supply elasticities for six staple agricultural products. High supply elasticities were obtained for beef and maize, which is explained by the relatively free market environment encountered by farmers. Low supply elasticities calculated for pork and potato, and very low

supply elasticities computed for wheat and milk point to a high degree of state regulation on these markets in the past and importance of quasi-fixed assets in production.

Townsend and Thirtle (1997) have conducted an empirical investigation of the production response of small scale producers of maize and cotton for communal agriculture in Zimbabwe. The error correction model, which employs the concept of cointegration to avoid spurious regressions, is used in the analysis. The factors affecting maize output were the price of maize relative to seed, the number of marketing depots established in the communal areas and the number of loans provided to these farmers. The weather played significant role in determining the quantity of maize sold.

Bhowmick and Goswami (1998) have selected the Nerlovian partial adjustment lag model in their Study of Supply Response of Some Important Crops in Assam – An Inter-District Analysis. Both linear and log linear model of the following types have been tried and the best-fitted model was selected for discussion.

Linear Model:

$$A_t = b_0 + b_1A_{t-1} + b_2FHP_{t-1} + b_3Y_{t-1} + b_4RLY_{t-1} + b_5RLP_{t-1} + b_6W_t + b_7Y_R + b_8P_R + b_9W_R + b_{10}t + U_t \dots (2.37)$$

Log Linear Model:

$$\log A_t = b_0 + b_1 \log A_{t-1} + b_2 \log FHP_{t-1} + b_3 \log Y_{t-1} + b_4 \log RLY_{t-1} + b_5 \log RLP_{t-1} + b_6 \log W_t + b_7 \log Y_R + b_8 \log P_R + b_9 \log W_R + b_{10} \log t + U_t \dots (2.38)$$

Where,

A_t = area under the crop in time t ('000 ha),

A_{t-1} = one year lagged acreage under the crop ('000 ha),

FHP_{t-1} = farm harvest price of the crop in the preceding year (Rs/qt),

Y_{t-1} = productivity of the crop in the preceding year (kg/ha),

RLY_{t-1} = one year lagged relative yield (ratio),

W_t = weather variable as three months average pre-sowing rainfall (mm),

Y_R = yield risk (co-efficient of variation of past three years yield of the crop),

P_R = price risk (co-efficient of variation of past three years farm harvest price of the crop),

W_R = weather risk (co-efficient of variation of past three years average of three months pre-sowing rainfall), and

t = time variable as a proxy for technological improvement ($t=1,2,3 \dots n$)

The problems of multicollinearity and auto correlation were taken care of by using appropriate statistical procedures.

Singh (1998) considered the Nerlovian lag adjustment model to study the supply response function of oilseeds in Uttar Pradesh. To examine the effectiveness of the additional variables, viz., price and yield variability to the area allocation of crop, the coefficient of variation of price (C_0V_P) and coefficient of variation of yield (C_0V_Y) over the preceding three years were included. The model adopted was:

$$A_t = B_0 + B_1T_t + B_2I + B_3A_{t-1} + B_4P_{t-1} + B_5Y_{t-1} + B_6P_{ct-1} + B_7C_0V_P + B_8C_0V_Y \dots (2.58)$$

Where,

A_t = area under oilseed crop for current year,

T_t = time trend variable,

I = current years irrigated area under oilseed crop,

A_{t-1} = area under oilseed crop lagged by one year,
 P_{t-1} = farm harvest price of oilseed crop lagged by one year,
 Y_{t-1} = yield of oilseed crop lagged by one year,
 P_{t-1} = farm harvest price of competing crop lagged by one year,
 C_0V_P = coefficient of variation of price of oilseed crop (price risk),
 C_0V_Y = coefficient of variation of yield of oilseed crop (yield risk), and
 B_i = regression coefficients ($i = 0, 1, 2, \dots, 8$).

Dixit *et al.* (1998) employed Nerlovian Expectation-cum-Adjustment model to analyse the time-series data on selected parameters for studying the production behaviour of groundnut farmers to price and non-price factors in Karnataka State.

Ashok (2004) studied the supply response of cassava in Tamil Nadu using Nerlovian price expectation cum area adjustment model for the period from 1985-86 to 2001-02. The results revealed that lagged area and lagged price had significant positive influence on area while the influence of rain fall and lagged yield were not significant.

2.3 Response variables (area and yield)

The total supply response is the response of the total output to price and non-price factors. In fact, it is the planned output that should respond to changes in these variables. In other words, growers tended to plan certain level of output to be produced in response to price and non-price factors and it was this planned output that had to be considered as a response variable. However, the non-availability of time series data on planned output made it necessary to use some appropriate proxy.

Regarding the response variable through which the farmers' decisions are reflected, however, there is little consonance amongst the researchers. Some researchers claim that area under the crop could be a better proxy for the planned output. They hold that area statistics were not only readily available and more dependable but also least influenced by external factors.

The protagonists of area response are. Sinha *et al.* (1934), Candler (1957), Nerlove (1958), Mangahas *et al.* (1966), Jakhade and Mujamdar (1964), Behrman (1968), Bhowmick and Ahamad (1993), Deshpande (1994) and Singh (1998).

On the other hand, Jha (1970), Sahay (1971), Maji *et al.* (1971), Madhavan (1972), Cummings (1975), Sawant (1978), and Dixit *et al.* (1998) mentioned that in modern agriculture, at the advent of land saving technologies, land becomes a secondary factor in production. Hence they pleaded for the yield/output response rather than the area response.

Another group of researchers, Batra (1976), Basavaraja (1982), and Kumar and Rosegrant (1997), however, worked on both area and yield responses in order to assess the farmers response to price and non-price factors.

Jha (1970) viewed that it might not be possible to obtain larger output through expansion of acreage in the long-run, the same might be realized by superior production technology. In other words, the response of output might be elastic in spite of inelastic acreage response. Hence he concluded that the impact of price could be more meaningfully measured in terms of variations in production rather than variations in terms of acreage.

Maji *et al.* (1971) argued that in the times of changing technology, there might be a considerable discrepancy between the acreage elasticities estimates based on the time series data and the actual current estimates. This problem would become severe if the technological change was one of the land savings types. The authors, hence, advocated that price elasticity of output would be more realistic than that of acreage.

Madhavan (1972) calculated the acreage as well as yield response to prices for different cereals and cash crops in Tamil Nadu using Nerlovian lagged adjustment model. The

results indicated that the cereal crops responded to variation in yield, while the cash crops were more responsive to variations in prices. Acreage elasticities of commercial crops were higher and hence he suggested the positive price policy to influence the cash crops' acreage and thereby the production. However, he opined that the limited supply of land makes it difficult to increase the acreage in response to price increase and hence he was in favour of increasing the output through increasing the yield rather than the acreage.

Batra (1976) argued that if land was heterogeneous and if other inputs constrained production, farmers might decide to increase the planned output of a specific crop by devoting less but better land to the crop. Therefore, he assumed that elasticity of planned output would be equal to the sum of elasticities of area and yield.

Sawant (1978) claimed that land would be good proxy for production so long as it is a major input and other inputs are closely complementary to it. But she argued that in a situation where it is not so, the use of non-land inputs should be explicitly considered while determining supply response. The results she obtained showed that the contribution of yield per acre to supply response was distinctly higher than that of acreage and thus suggested the inadequacy of acreage response.

Basavaraja (1982) felt that it would be better to estimate both acreage and yield responses with a view to properly gauging the impact of price and non-price variables on the supply of cotton in Karnataka State. He estimated production response in addition to area and yield responses for the purpose of comparison.

Lal (1987) in the study on response of sugarcane producers to price and non-price factors, examined the impact of price and non-price factors on sugarcane acreage and estimated the short and long run supply elasticities. It was found that the major factors significantly and positively influencing sugarcane area in different districts of Uttar Pradesh were the farmers' own adjustment lags in area (their previous year cane acreage), relative sugarcane profitability, rainfall during sowing months and time trends. The study suggests that the price of competing crops must be taken into account when evolving a suitable price structure for sugarcane. The risk arising out of price fluctuations needs to be minimized. If the farmers of the area are assured of irrigational facilities from canals or other sources, there is great scope for increasing sugarcane area in spite of low rainfall in the pre planting period.

Bhowmick and Ahamed (1993) studied the supply response of major oilseed crops in Assam for the period 1972-73 to 1988-1989. The results showed that increase in oilseeds production had been related to increased acreage rather than intensification of production.

Deshpande (1994) in his study on supply response of chilli in Karnataka State for the period 1969-70 to 1990-91, concluded that the increase in the total output of chilli in the state was the result of shifting land from other crops rather than by increasing the yield of the crop.

Kumar and Rosegrant (1997) worked on the dynamic supply analysis of cereals with an intention to separate the output decision in to area and yield per hectare decisions. They assumed that the farmer first decides on area allocation among the crops and then the intensity of inputs used and hence yield.

Singh (1998) approximated the output decisions of farmers in terms of area under the crop rather than its yield while studying supply response of oilseeds in Uttar Pradesh. According to him this is because the area enjoyed by the crops can be considered as a barometer of the farmers land allocation decision. Further, the area allocation under a crop is a function of several endogenous factors, whereas, the yield is influenced by several exogenous factors. But, Singh also believed that the farmers could keep area constant and increase output by varying yield level.

El-Batran (2003) conducted a study on supply response for wheat in Egypt. Wheat acreage supply response in Egypt during the period 1980-2001 examined using different models. The results indicated that there a positive supply response to the relative price of wheat and competing crops (i.e. sugarcane and faba beans) and to the relative net profit between wheat and multi cut berseem, and that the positive supply response also reflects the role of technical change in increasing the cultivated area under wheat.

Munis Alagh (2004) in the study on aggregate agricultural supply function in India, examined whether the aggregate agricultural supply function in India was price elastic. An acreage response function for the period 1950-51 to 1996-97 corroborates the findings of earlier scholars that India's aggregate supply function is not price responsive. However, periodizing the framework of analysis, due to changed growth rates and policies after 1980-81, suggests a weak relationship between acreage response and terms of trade for the latter period. It is still incorrect to say that Indian agriculture responds at the aggregate level to price stimuli but ignoring the marketization of substantial sections of the economy is also not useful. The agrarian economy reflects the transitional nature of the policy regime since 1980 and this paper offers some tools to understand it.

2.4 Price factor

Another controversial issue, among the researchers in supply response studies, is the price factor. In fact, it is needless to say that price has been rated as an effective incentive in furthering agricultural production by a number of researchers. But, the question as to which price (the pre-sowing prices, the post harvest prices, the annual average prices, the absolute prices or the relative prices), influences the farmer's decision-making process, remains to be unresolved debate regarding the price factor specification.

Acharya and Bhatia (1974) in their study, Acreage Response to Price, Yield and Rainfall Changes in Rajasthan, used harvest prices assuming that the harvest prices to be exercising more influence on the decisions of the farmers as majority of the farmers dispose off their produce immediately after harvest. In order to compare the effect and obtain better estimates, both relative and absolute prices were studied. The price-relative for each crop was computed by deflating the price of the crop in question with respect to the price of its most competing crop.

Sawant (1978) thought that it was the real price and not the money price that guided the farmers' decisions as to how much to produce. The most appropriate deflator to calculate real price was the index of the prices of inputs used in the production. In the absence of time-series data on factor prices, she used Economic Advisor's All Commodity Index of wholesale prices as a deflator.

Gajja *et al.* (1983) found that decisions regarding area allocation for groundnut in Rajasthan corresponded strongly with the harvest price lagged by one year. They concluded that price behaviour was a decisive factor for area allocation for groundnuts in conjunction with such factor as its own productivity performance, prices of competing crops and rainfall patterns in Rajasthan.

Naik and Patnaik (1984) opined that, in Orissa most potato growers tended to sell potatoes just after harvest due to lack of adequate storage facilities and to meet urgent cash requirements. The harvest price had therefore an explanatory significance in a study of price impacts on area allocation and output. The result of the study revealed that output and area under potatoes were dependent upon the harvest price of potatoes lagged by one year in this area.

Mahajanshetti (1987) studied the supply response of jowar in Karnataka. He used the area under competing crops of jowar to deflate the relative price factors and incorporated this relative price of jowar into the area, yield and production response models.

Janaiah *et al.* (1991) while studying the farm supply response of cotton in Andhra Pradesh for the period 1956-57 to 85-86, used both the farm harvest price of cotton and its competing crop (chillies). The results revealed that the previous year's price had exerted significant positive influence on current area in the state as a whole and its regions except in Rayalaseema, whereas the price of competing crop (chillies) in Rayalaseema region and the state as a whole was observed to have negative relationship with current year's area.

Murthy *et al.* (1992), in the study on supply response of turmeric in Guntur district of Andhra Pradesh, estimated the supply response of turmeric to price and non-price factors in Guntur district of Andhra Pradesh state, using data for the period 1972/73-1984/85. Neither yield nor acreage found to be responsive to the level of prices observed.

Tripathy and Gowda (1993) by making use of one year lagged harvest price in their model to study the area response of groundnut in Orissa obtained a positive and significant impact of harvest price on the area under groundnut. The short-run elasticity was 0.334 while the corresponding long-run elasticity turned out to be 0.3619.

Monthly groundnut wholesale price data for all districts of Orissa state (India) for the period 1974-90 were collected and used in the analysis of groundnut prices in Orissa market and its impact on area and production by Mohanty (1995). The findings revealed that both monthly and annual wholesale prices of groundnut vary significantly in most districts as well as at the state level. A significant relationship between groundnut price and groundnut area and production was observed.

Omezzine (1996) studied the winter tomato farmers' response in Tunisia. The adaptive expectation geometric distributed-lag model was used to test farmers' reaction to expected prices of inputs and outputs as well as to other determinants of supply. Results indicated that farmers reaction to the price they expect depends on previous years prices.

Dhindsa and Sharma (1997) had used lagged relative price to study the supply response of prices in Punjab state and arrived at non-significant negative impact of the variable on area under gram in two regions and the state as a whole. They contend that the non-significant impact of relative price variable would show that the farmers in various regions of Punjab did not take into consideration the changes in relative price of the crop (gram) while allocating area under this crop.

An empirical investigation on the supply of maize and tobacco for commercial agriculture in Zimbabwe is presented by Townsend *et al.* (1997). The error correction model, which employs the concept of co integration to avoid spurious regressions, was used in the analysis. The factors affecting percentage area planted to maize were, expected real maize price, real price of tobacco, real price of fertilizer and government intervention. The factors affecting percentage area planted to tobacco were real price of tobacco, expected real price of maize and institutional factors. The price elasticity of maize was 1.44 and 1.76 in the short and the long run respectively. For tobacco, these were 0.28 and 1.36 in the short and long run, respectively.

Singh (1998) employed the Nerlovian lag adjustment model while using farm harvest price to study the supply response of oilseeds in Uttar Pradesh for the year 1966-67 to 1989-90. The result revealed that the price variable had negative impact on area allocation for groundnut, linseed and rapeseed-mustard but it was statistically significant only in the case of groundnut. It had positive significant impact on sesame area.

Mesfin Arega (2000) studied the supply response of maize in Karnataka. The study was carried out mainly to evaluate the impact of relative price and selected non-price factors and to analyse the short and long run price elasticities. The results indicated that relative price factor had positive and significant bearing on hectareage of maize in none of the selected districts but at the state level. Districts viz., Belgaum and Bijapur evidenced significant negative impact of price on hectareage of maize.

Suleiman Abrar *et al.* (2004) explained the crop level supply response by region wise in Ethiopia. The results showed that the out put prices are clearly an important part of the incentive structure, but non-prices factors are the binding constraints. This is most apparent in the relatively non-commercial Northern highlands where these factors are far more important in affecting production and resource use than price incentives.

2.5 The supply shifters

The total variation in the output was being considered as a consequence of changes not only in the price factor but also in several non-price factors that have their bearing on production activity. It could be said that the price variation at best, explains only a part of the variation in the response variable. The vagaries of climatic factors and incidence of pests and diseases adversely affect the agricultural production in the short-run and the technological advancements cause long-run supply changes. In economic terminology these factors are referred to as 'Supply Shifters'. In this section the views of different investigators on the supply shifters to be considered in the supply response analysis are presented.

Sawant (1978) took average rainfall in the three pre-sowing months to account for the weather factor in hectareage response. Accordingly it was not the total rainfall received during the growing period of the crop that was important, but its distribution pattern that accounts much in yield variability. Therefore, she took the deviation of the growing periods rainfall average, from its respective normal rainfall because the excess or scanty rainfall would equally damage the prospects of a good crop.

Lahiri and Roy (1985) opined that, agriculture in many developing countries still being predominantly rain dependent and unless rainfall is introduced into the supply response functions carefully, the equations would be mis-specified, leading to bias in the computation of elasticities.

Raju and Nagabhushanam (1986) indicated that various technological and institutional factors influenced the decision-making behavior of farmers growing oilseeds in Andhra Pradesh. They included variables such as, the lagged area and the lagged yield of the crop, the sowing period rainfall and the time trend as non-price variables. The regression coefficients of the lagged area of the crop were found highly significant in almost all the cases.

Reddy (1989) examined the relative importance of price, irrigation, yield and rainfall to the area allocation under paddy in Andhra Pradesh during 1963-64 to 1983-84. The rainfall caused the greatest proportion of change in the acreage under paddy as revealed by the elasticity coefficient. The short-run rainfall elasticities were 0.69 for Rayalaseema region, 0.35 for Telangana region and 0.33 for the state as a whole. The corresponding long-run elasticities were 1.09, 0.59 and 0.55 respectively.

Cauvery (1992) who has studied the acreage response of groundnut in North Arcot district (Tamil Nadu), found that rainfall which was included in the model as one of the non-price variables had a negative relationship with acreage. He has concluded that groundnut in this area were grown as a dry crop, and high rainfall during the pre-sowing period induced farmers to shift their land to other crops.

Ghatak and Seale (1993) found the role of risk in farmer's decision making as an important determinant factor. They opined that if farmers are rational and risk averters in developing countries, they have to consider not only expected output prices and yields while allocating resources, but also expected risk in output prices and yields.

Tripathi and Gowda (1993) studied the area response of groundnut in Orissa during the year 1970-71 to 1989-90. The results of the study showed that lagged area, lagged price, price risk and irrigation variables had positive and significant impact on area allocation under groundnut. The effect of rainfall turned out to be negative but statically non-significant implying that excess rainfall during sowing time inhibited area expansion of groundnut.

Patel and Singh (1994) found out that the lagged relative gross returns influenced the current area of bajra significantly in all the districts of Gujarata State except Mahesana district where bajra was considered as a subsistence crop. The current bajra area in all the districts and the State as a whole was inelastic.

Acreage response equations for nine major crops in Wisconsin, USA, were estimated to determine the impacts of Government programmes and site characteristics (e.g. soil types, slope and rainfall) on cropping patterns by Wu and Brorsen (1995). Site characteristics accounted for more than twice as much acreage variation as the economic and policy variables.

Prakash *et al.* (1997) conducted a study to disprove the hypothesis that farmers in the developing countries, such as India, do not respond to changes in the economic environment in general and to changes in factor and product prices. The results of the study showed that changes in prices are neither the necessary nor sufficient condition of change in the area under cultivation; relative rather than absolute prices and yields govern the cropping pattern. The distinction between stationary and dynamic conditions of growth of the farm economy is essential for delineating the magnitudes and interrelations between price, area under cultivation and yield. Yield is the decisive determinant of acreage than price in the case of

crops such as rice, wheat and maize, which have registered dramatic growth in yield under the impact of green revolution technologies.

Gafar (1997) used lagged output and trend variables as non-price factors affecting supply of aggregate agricultural output in Jamaica. The time trend was added in the model to account for such effects as advances in agro-technology. The estimated coefficient for lagged output had the correct (positive) sign and was plausible.

Singh (1998) examined the area response of oilseeds in Uttar Pradesh by making use of current year's irrigated area under oilseed crop, area under oilseed crop lagged by one year, yield of oilseed crop lagged by one year, coefficient of variation of price of oilseed crop (price risk), coefficient of variation of yield of oilseed crop (yield risk) and trend variables as supply shifters.

Dixit *et al.* (1998) incorporated five non-price factors in their model to examine the supply response of groundnut in Karnataka state. These variables were (i) expected groundnut production lagged by one year, (ii) pre-sowing months' average rainfall, (iii) deviation of actual rainfall from normal during the growing season, (iv) relative anticipated risk and (v) time trend. The estimated short-run elasticities were -0.64 , -0.06 , -0.02 and 0.26 for pre-sowing months' rainfall, deviation of actual rainfall, relative risk and trend variables respectively for the state as a whole.

Leaver (2004), in the study on measuring the supply response functions of tobacco in Zimbabwe, presented an estimate of the price elasticity of supply for tobacco output in Zimbabwe using an adapted Nerlovian model. The results indicate a short-run elasticity of $+0.34$ and a long-run elasticity of $+0.81$, suggesting that tobacco farmers are highly unresponsive to price changes. These estimates are similar to those obtained for tobacco in supply response studies conducted in other developing African countries.

3. METHODOLOGY

In this chapter the details of the study area, nature and source of data and techniques of analysis are presented under the following broad heads

3.1 General characteristics of the study area

3.2 Nature and source of data

3.3 Techniques of analysis

3.1 General characteristics of the study area

The present study is related to Karnataka state in which three major onion growing districts, namely, Bijapur, Chitradurga, Dharwad were considered for in depth analysis.

The State is situated in the Southwestern part of India between 11°3' and 18°45' North latitude and 74°12' and 78°40' East longitudes. It is bound by Maharashtra and Goa on the north, Andhra Pradesh on the east, Tamil Nadu and Kerala States on the south and Arabian sea on the west.

Karnataka State with an area of 1, 91,791 sq.km extends to about 700 km from north to south and 400 km from east to west. It accounts for 5.83 per cent of the total area of the country (32, 87,263 sq.km) which makes it to rank seventh among the major States of India, in terms of size.

The rainfall in the State ranges from 466.5 mm to 4694.4 mm with an average annual rainfall of 1354.7 mm. The average minimum temperature for the State in winter is 17.5°C which varies from 20.3°C in the coast to 14.3-16.3°C in the interior. The temperature increases after February reaching the highest point in April in the Southern plains and May in the northern plains. The mean maximum temperature is higher than 40°C in Bidar Gulbarga region. It progressively declines towards South-Western parts the lowest being 28.3°C at Agumbe (hill regions). The soils in the State range from red sandy loam to deep black soils.

Out of the 191,791 sq. km of the State's total area; forests cover 16.08 per cent, area not available for cultivation accounts for 10.86 per cent, other un-cultivated land excluding fallow 9.32 per cent, fallow land 8.06 per cent and net sown area accounts for 55.69 per cent.

In Karnataka state three major onion growing districts (Bijapur, Chitradurga, Dharwad) were selected for the present study based upon the percentage of the average onion area and production in the district over a period of 10 years (1996-97 to 2004-05). Each of the selected districts accounts for more than 6 per cent of the State's onion area and production. These three districts together accounts for 70 per cent of area under onion in the state.

3.2 The nature and source of data

The study is completely based on secondary data. The district wise time series data from 1980 to 2005 pertaining to the area, production and productivity of onion were collected from the Bureau of Economics and Statistics, Government of Karnataka, Bangalore. In addition the data on month wise rainfall and irrigated area under onion were extracted from the records maintained by the Bureau.

3.3 Techniques of analysis

Keeping in view the objectives set for the study, the techniques of the analysis are presented under the following heads:

- a) Growth rate analysis
- b) Supply response analysis



Fig. 1: Map of Karnataka state showing the study area

Table 3.1 District wise area and production during the period year 1997-98 to 2004-05

District	Area (ha)	(Average)
		Production (tones)
Dharwad	55914.5	171738.375
Chitradurga	19167.88889	147325.1111
Bijapur	12340.66667	132832.6667
State	111480.1111	735861.5556

Source : Directorate of Economics and Statistics, Government of Karnataka, Bangalore

3.3.1. Growth Rate Analysis

In order to analyze the growth in area, production and productivity of onion in each selected district and the state as a whole, compound growth rates were computed using the method by least squares of fitting the semi-logarithmic function:

$$Y = a b^t e_t$$

Where,

Y = dependent variable (area/ production/ yield)

a = intercept term

b = (1+r) and r is the compound growth rate.

t = time trend (t = 1,2,3,.....n)

e_t = error term

In the logarithmic form the function could be expressed as,

$$\log Y = \log a + t \log b$$

log a and log b were obtained using the ordinary least squares procedure, and the R² was computed to test the goodness of fit. (Antilog of log b -1) x 100 gave the percent growth rate.

3.3.2 Supply Response Analysis.

In this study it was proposed to employ the combined Nerlovian Model, i.e., the Nerlovian price Expectation-cum-Area Adjustment Model, to estimate the area, yield and production response functions with the help of single equation model.

3.3.3 Area Response Function

The area response function was specified as follows:

$$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*) \dots \dots \dots (3.1)$$

$$A_t - A_{t-1} = \gamma(A_t^* - A_{t-1}) \dots \dots \dots (3.2)$$

$$A_t^* = a_0 + a_1 P_t^* + a_2 Y_t + a_3 W_{1t} + a_4 I_t + a_5 R_t + a_6 T_t + U_{1t} \dots (3.3)$$

Where,

- A_t^* = desired area under the crop,
- P_t^* = the expected price,
- β = the coefficient of expectation, and
- γ = the coefficient of adjustment.

The area equation (3.3) could not be directly estimated since it contained two unobservable variables, viz., desired area (A_t^*) and expected price (P_t^*). The estimable reduced form could be derived by substituting equations (3.1) and (3.2) into equation (3.3) and manipulating the equation algebraically to express it in terms of observable variables as under (the full derivation is given in Appendix I):

$$A_t^* = b_0 + b_1 P_{t-1} + b_2 A_{t-1}^* + b_3 Y_t^* + b_4 W_{1t}^* + b_5 I_t^* + b_6 R_t^* + b_7 T_t^* + e_{1t}^* \dots (3.4)$$

Where,

- $A_t^* = A_t - (1-\beta)A_{t-1}$ = desired area in the period t,
- $A_{t-1}^* = A_{t-1} - (1-\beta)A_{t-2}$ = desired area in the period t-1,
- $Y_t^* = Y_t - (1-\beta)Y_{t-1}$ = the yield variable,
- $W_{1t}^* = W_{1t} - (1-\beta)W_{1t-1}$ = the rainfall variable,
- $R_t^* = R_t - (1-\beta)R_{t-1}$ = the relative return risk variable,
- $I_t^* = I_t - (1-\beta)I_{t-1}$ = the irrigation variable,
- $T_t^* = T_t - (1-\beta)T_{t-1}$ = the trend value,
- $e_{1t}^* = e_{1t} - (1-\beta)e_{1t-1}$ = the random error term,
- P_{t-1} = the relative price in period t-1,
- A_t = the actual area in period t,
- β = the coefficient of expectation, and
- γ = the coefficient of area adjustment.

$$b_0 = a_0 \gamma \beta, b_1 = a_1 \gamma \beta, b_2 = (1-\gamma), b_3 = a_2 \gamma, b_4 = a_3 \gamma, b_5 = a_4 \gamma, b_6 = a_5 \gamma \text{ and } b_7 = a_6 \gamma$$

The above estimating linear equation (3.4) was also specified in the non-linear equation form as follows:

$$A_t^* = b_0 \cdot P_{t-1}^{b1} \cdot A_{t-1}^{b2} \cdot Y_t^{b3} \cdot W_{1t}^{b4} \cdot I_t^{b5} \cdot R_t^{b6} \cdot T_t^{b7} \cdot e_{1t}^* \dots (3.5)$$

3.3.4 Yield Response Function

The yield response function was specified as follows:

$$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*) \dots \dots \dots (3.6)$$

$$Y_t - Y_{t-1} = \alpha(Y_t^* - Y_{t-1}) \dots \dots \dots (3.7)$$

$$Y_t^* = C_0 + C_1 P_t^* + C_2 W_{2t} + C_3 I_t + C_4 R_t + C_5 T_t + U_{2t} \dots \dots \dots (3.8)$$

Where,

- Y_t^* = the desired yield, and

P_t^* = the expected price

After simplification of the above relations, the estimating equation would be as follows:

$$Y_t^* = b_0 + b_1 P_{t-1} + b_2 Y_{t-1}^* + b_3 W_{2t}^* + b_4 I_t^* + b_5 R_t^* + b_6 T_t^* + e_{2t}^* \dots (3.9)$$

Where,

$Y_t^* = Y_t - (1-\beta) Y_{t-1}$ = desired yield in the period t,

$Y_{t-1}^* = Y_{t-1} - (1-\beta) Y_{t-2}$ = desired yield in the period t-1,

$W_{2t}^* = W_{2t} - (1-\beta) W_{2t-1}$ = the rainfall deviation,

$I_t^* = I_t - (1-\beta) I_{t-1}$ = the irrigation variable,

$R_t^* = R_t - (1-\beta) R_{t-1}$ = the relative return risk variable,

$T_t^* = T_t - (1-\beta) T_{t-1}$ = the trend variable,

$e_{2t}^* = e_{2t} - (1-\beta) e_{2t-1}$ = the random error term,

P_{t-1} = the relative price in period t-1,

Y_t = the actual yield in period t,

β = the coefficient of expectation,

α = the coefficient of yield adjustment.

$b_0 = C_0 \beta \alpha$, $b_1 = C_1 \beta \alpha$, $b_2 = (1-\alpha)$, $b_3 = C_2 \alpha$, $b_4 = C_3 \alpha$, $b_5 = C_4 \alpha$ and $b_6 = C_5 \alpha$

The above estimating linear equation (3.9) was also specified in the non-linear equation form as follows.

$$Y_t^* = b_0 \cdot P_{t-1}^{b_1} \cdot Y_{t-1}^{b_2} \cdot W_{2t}^{b_3} \cdot I_t^{b_4} \cdot R_t^{b_5} \cdot T_t^{b_6} \cdot e_{2t}^* \dots (3.10)$$

3. 3.5 Production Response Function

The production response function was specified as follows:

$$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*) \dots (3.11)$$

$$Q_t - Q_{t-1} = \lambda(Q_t^* - Q_{t-1}) \dots (3.12)$$

$$Q_t^* = d_0 + d_1 P_t^* + d_2 W_{2t} + d_3 Y_t + d_4 R_t + d_5 T_t + U_{3t} \dots (3.13)$$

Q_t^* = the desired production of the crop, and

P_t^* = the expected price.

After simplification of the above relation the estimating equation would be as follows:

$$Q_t^* = b_0 + b_1 P_{t-1} + b_2 Q_{t-1}^* + b_3 W_{2t}^* + b_4 Y_t^* + b_5 R_t^* + b_6 T_t^* + e_{3t}^* \dots (3.14)$$

Where,

$Q_t^* = Q_t - (1-\beta) Q_{t-1}$ = the desired production in period t,

$Q_{t-1}^* = Q_{t-1} - (1-\beta) Q_{t-2}$ = the desired production in period t-1,

$Y_t^* = Y_t - (1-\beta) Y_{t-1}$ = the yield variable,

$W_{2t}^* = W_{2t} - (1-\beta) W_{2t-1}$ = the rainfall deviation,

$R_t^* = R_t - (1-\beta) R_{t-1}$ = the relative return risk variable,

$T_t^* = T_t - (1-\beta)T_{t-1}$ = the trend value,

$e_{3t}^* = e_{3t} - (1-\beta)e_{3t-1}$ = the random error term,

β = the coefficient of expectation

λ = the coefficient of production adjustment

P_{t-1} = the relative price in period t-1, and

Q_t = the actual production in period t.

$b_0 = d_0\beta\lambda$, $b_1=d_1\beta\lambda$, $b_2=(1-\lambda)$, $b_3=d_2\lambda$, $b_4=d_3\lambda$, $b_5=d_4\lambda$ and $b_6=d_5\lambda$

The above estimating linear equation (3.14) was also specified in the non-linear equation form as follows:

$$Q_t^* = b_0 \cdot P_{t-1}^{b_1} \cdot Q_{t-1}^* \cdot W_{2t}^{*b_3} \cdot Y_t^{*b_4} \cdot R_t^{*b_5} \cdot T_t^{*b_6} \cdot e_{3t}^* \dots (3.15)$$

Ordinary Least Squares (OLS) technique was used for estimating the parameters of the models. The problem now would be as to how to restrict the range of the coefficient of expectation. If $\beta=0$, then we would arrive at $P_t^* = P_{t-1}^*$ which implied that the preceding year's price had no relevance to the current expectation and that expectations would never change. If $\beta=1$, then $P_t^*=P_{t-1}$ which implied that preceding year's price itself was the farmers' expected price for the current year and hence is amounted to a simple cobwebs model. Moreover if $\beta=1$, then we would arrive at $A_t^*=A_t$ which would be simply an adjustment model and there would be no concept of expectation. If $0<\beta<1$, the expectations involved the incorporation of some fraction of last year's "error". If $\beta>1$, the process was marked out by over-expectation, i.e., the expected price of this year and that of last year differed by more than what did the last years actual price and the expected price. If $\beta<0$, then the relationship was perverse, with the expectations moving down if last year's expectations proved too pessimistic and moving upward if last year's expectations were unduly optimistic. Therefore, one would expect that the value of β to be greater than zero but rarely much greater than unity. So, the estimating equations of area, yield and production response functions, can be estimated for several pre-selected values of β between zero and two and then choose the value which minimizes the error sum of squares.

The area, yield and production response estimating equations in the present study were estimated assigning β values between 0.5 and 1.5 at an interval of 0.1, in both linear and non-linear forms. Then equation which minimized the error sum of squares, in other words, which maximized the value of R^2 , was selected for further analyses to estimate the short and long-run elasticities of area, yield and production of onion with respect to price and non-price variables.

In the case of linear functions, the short-run price elasticities of area, yield and production were computed as follows.

Short-run price elasticity of yield	=	Regression coefficient of price	X	$\frac{\text{Mean price}}{\text{Mean hectareage}}$
Short-run price elasticity of yield	=	Regression coefficient of price	X	$\frac{\text{Mean price}}{\text{Mean yield}}$
Short-run price elasticity of yield	=	Regression coefficient of price	X	$\frac{\text{Mean price}}{\text{Mean production}}$

The short-run non-price elasticities of area, yield and production for linear functions are also computed in the same way as shown above.

In the case of log-linear functions, the regression coefficients of price and non-price variables represented the respective short-run elasticities.

The long-run elasticities were obtained by dividing the corresponding short-run elasticities with the coefficient of adjustment.

3.3.6 Competing Crops

The major crops of selected districts and the State as a whole were identified by examining the movements of onion area vis-à-vis other crops in the district and State as a whole, and based on the coefficient of correlation which was highly negative, that particular crop was selected as competing crop. By the above criteria and discussion with agronomists two competing crops viz., chilli, potato for Dharwad, chilli and cotton for Bijapur, chilli and groundnut for Chitradurga and chilli and cotton for the State as a whole were selected.

3.3.7 Specification of Variables Used in the Models

The price and non-price variables selected for the study are defined as under.

3.3.7.1 Price variable (P_i)

Price is one of the important variables, which influences the production decisions of the farmers. The question which of the price specifications (prices) would effectively enter the resource allocation decision making process of the farmer to the various production channels is crucial in comprehending the supply-price relations. It was observed from different studies that usually the farmers, in order to meet their immediate financial demands and due to inadequate storage and credit facilities, compelled to sell away their produce soon after the harvest. In the case of onion also, after drying the produce, farmers would dispose it off immediately. Therefore, in the present study it was proposed to use the "farm harvest price" of the crops (onion and its competing crops).

Since crops can be substituted in production in a given season, it is necessary to take into account the prices of the competing crops in the analysis. In order to avoid the risk of multicollinearity in the separate specifications of the prices of all competing crops in a single equation, it was felt appropriate to use a single relative price. Three alternative ways of relating the price of onion crop to the prices of the competing crops were examined separately, weighting the competing crop prices by their hectareage, yield and production, in order to avoid under or over emphasis of any single competing crop. The 'hectareage' as a weight gave the best results in terms of coefficient of correlation and the relative onion prices obtained formed the price variables in the area, yield and production response models in the study.

The deflated relative prices of onion were obtained as given below:

$$\text{Relative price of onion} = \left[\frac{P_o}{\frac{X_1 P_{x1} + X_2 P_{x2}}{X_1 + X_2}} \right]$$

Where,

P_M = the farm harvest price of onion,

X₁ = the area under competing crop-I,

P_{x1} = the farm harvest price of competing crop-I,

X₂ = the area under competing crop-II,

P_{x2} = the farm harvest price of competing crop-II

The role of relative price in affecting the decision making process of farmers was well supported by previous works on the supply response studies (Basavaraja, 1982; Mahajanshetti, 1987; Reddy, 1989; Deshpande, 1994 and Dixit, 1998).

3.3.7.2 Expected yield as a variable (Y^*_t)

In the previous supply response studies expected yield received due importance. This was because, the expected yields were assumed to influence the decisions of producers regarding resource allocation. In this study too, it is believed that farmers favorably react to the expected yield levels in allocating the land and non-land inputs, and the previous five years average yield of onion was taken as a measure of expected yield. This variable was included in the area and the production response models to ascertain its impact on variations in the area under onion as well as the production of onion. Earlier researchers (Rajkrishna, 1963; Jha, 1970; Raju and Nagabhushanam, 1986; Reddy, 1989 and others) supported the inclusion of expected yield as a variable in the supply response studies.

3.3.7.3 Weather

Weather includes temperature, relative humidity, wind, rainfall etc. Since the rainfall affects considerably the area to be cultivated and the yield to be realized when compared to other factors, it is used in this study as a proxy for weather.

The rainfall data available is separately specified for the hectareage and yield response models as follows:

- i) Rainfall in pre-sowing months (W^*_t): It was not the total annual rainfall that was important, but the rainfall received during the pre-sowing months is relevant. This was so because, it was felt that favourable moisture conditions during sowing time would encourage farmers to bring more area under cultivation of the crop in question (Singh and Bhatnagar, 1983). Therefore, the average rainfall received in the four pre-sowing months (June, July August and September) is used in the hectareage response model as a proxy for the weather factor. This variable emerged as an important variable, which caused a considerable amount of change in the acreage under the crop in the previous supply response studies (Singh and Bhatnagar, 1983; Reddy, 1989 and Cauvery, 1992).
- ii) Deviation of the actual rainfall from the normal rainfall ($W_2^*_t$): Extreme deviation of actual rainfall from the normal rainfall, whether positive or negative, would damage the prospects of a good crop (Sawant, 1978). It is not the total amount of rainfall received during the growing period of the crop that determines the yield variability, but it is the distribution of the rainfall over the crop growth period. Therefore, in the present study the average of absolute deviation of monthly actual rainfall from the normal monthly rainfall during the crop growth period (June, July, August and September) was considered. It was obtained as follows:

$$\text{Absolute average monthly rainfall deviation} = \frac{1}{4} \sum_{n=1}^4 \left[\text{Actual rainfall in the month} - \text{Normal rainfall in the month} \right]$$

Where,

$n=1,2,3,4$ represent the crop growth period of onion from June to September.

This weather factor ($W_2^*_t$) was incorporated into the yield and the production response models.

3.3.7.4 Irrigation factor (I^*_t)

In the present study it was expected that with an increase in the amount of irrigation, the area under onion and the yield of onion would increase. Therefore an attempt has been made to assess the impact of irrigation on the area and yield of onion. The total irrigated area

under onion was considered as an explanatory variable of irrigation factor in area and yield response models.

3.3.7.5 Relative return risk factor (R^*_t)

The relative return risk was considered to assert its impact on variations in the area, yield and production of onion. If farmers are rational and risk averse in developing countries, they should consider not only expected output prices and yields when allocating resources, but also expected risk in output prices and yields (Ghatak and Seale, 1993). Hence, risk as a non-price variable was included in the area, yield and production response models. By incorporating both price and yield risks, the relative return risk factor for onion was calculated as the ratio of standard deviation of three previous years gross returns of onion to that of its competitive crop(s).

$$\text{Relative return risk factor} = \frac{\text{Standard deviation of three previous years gross returns of onion}}{\frac{1}{2} \left[\text{Standard deviation of three previous years gross returns of competing crop-I} + \text{Standard deviation of three previous years gross returns of competing crop II} \right]}$$

The inclusion of relative return risk factor as one of the non-price factors in the supply response studies is supported by Basavaraja (1982) and Dixit *et al.* (1998).

3.3.7.6 Trend variable (T^*_t)

In addition to the above price and non-price variables, a time trend variable was considered as an explanatory variable in the present study. This was because the leftover variables like, the marketing system, institutional factors and technology, which change over time and poses quantification problem, have to be taken care of by some proxy variable(s). The time trend, therefore, has been considered as an independent variable to take care of such left over variables and it was used as a "catch all" variable (Sawant, 1978) in all the three response functions.

This variable, in the present study was specified by giving the values 1,2,3 25 serially for the years of the study period starting from 1980-81 to 2004-05. Sahay (1971), Sawant (1978), Basavaraja (1982) Dhindsa and Sharma (1997), Dixit *et al.* (1998) and other researchers also included the time trend variable in their supply response studies.

4. RESULTS

The results obtained from the analysis of the data pertaining to the study are presented in this chapter. The combined Nerlovian Price Expectation-cum-Area Adjustment Model was employed to estimate the area, yield and production responses of onion with single equation approach in this study. The coefficient of expectation, β , was assigned the values in the range of 0.5 to 1.5 at an interval of 0.1 in both linear and log-linear forms of the functions. Thus, there were twenty-two equations each for the area, yield and production response functions in the case of each district and the State as a whole. Totally as much as 264 equations were estimated and the equation, which gave the minimum error sum of square was selected from each set of the twenty-two equations for further analysis. Hence, in the present study which covers the three selected major onion growing districts and the Karnataka State as a whole, seven equations were fitted each for area, yield and production response functions. The results obtained are presented under the following broad heads:

4.1 Growth in area, production and productivity of onion

4.2 Hectareage response of onion

4.3 Yield response of onion

4.4 Production response of onion

4.1 Growth in area, production and productivity of onion

4.1.1 Growth rate analysis

Table-4.1 indicates that growth rates of area, production and productivity of onion in Dharwad, Bijapur and Chitradurga Districts and at the state level for the period from 1980-81 to 2004-05.

Dharwad district registered a positive and highly significant growth rates in area and production of onion. The growth rate in productivity was also positive and found to be highly significant and the rate was of higher magnitude.

The growth rates in area, production and productivity of onion in all the cases of Chitradurga turned out to be positive and statistically significant. However, the growth rates were not of higher magnitude.

Bijapur district registered a low magnitude positive and highly significant growth rates in area and production of onion. However, growth rate was found to be of lower magnitude and significant.

Area under onion and production of onion showed highly significant positive growth rates in the case of the state as a whole. However the state registered a non-significant positive growth rate in the productivity of onion.

4.2 Hectareage response of onion

The estimated hectareage response functions of onion for each of the selected districts and the state as a whole are presented in Table 4.2. The estimated short and long-run price elasticities and non-price elasticities of onion hectareage response are presented in Table 4.3 and 4.4 respectively.

The functions selected for Dharwad, Chitradurga and the State as a whole were linear, while the Bijapur district it was log-linear. The values of R^2 (the coefficients of multiple determination) generally ranged between 0.8542 (Chitradurga) to 0.9622 (Dharwad), all significant at one per cent level. The best value for ' β ', the coefficient of expectation, was found to be 1.5 for Dharwad, Chitradurga and the State as a whole. While, the coefficients of area adjustment (γ) ranged between 0.6566 (Chitradurga) to 0.9622 (Dharwad).

Table 4.1: Compound growth rates of area, production and productivity of onion (from 1980-81 to 2004-05)

District	Growth	
	Parameters	Growth Rate
Dharwad	Area	4.15 ^a
	Production	4.63 ^b
	Productivity	2.33 ^a
Chitradurga	Area	1.75 ^a
	Production	2.43 ^a
	Productivity	2.25
Bijapur	Area	1.02 ^a
	Production	1.18 ^b
	Productivity	1.75 ^a
State	Area	2.69 ^a
	Production	2.88 ^a
	Productivity	0.18

Note – a- significant at 1%
b- significant at 5%

Table 4.2 Estimated hectareage response functions of Onion

Sl. No.	District	Functional form	Coefficient of expectation (β)	Coefficient of area adjustment (γ)	Coefficient of determination (R^2)	Constant	One year lagged relative price (P_{t-1})	One year lagged desired area (A^*_{t-1})	Current year desired yield (Y^*_t)	Average pre-sowing months rainfall (W_{1t}^*)	Relative return risk factor (R^*_t)	Irrigation factor (I^*_t)	Trend variable (T^*_t)
1	Dharwad	Linear	1.0	0.9662	0.9543	-6170.52 (11709.58)	1060.90 ^b (11026.83)	0.0378 (0.3962)	1.355 ^c (1.522)	18.039 ^b (8.4032)	-396.09 (1672.44)	-0.3332 (0.4642)	2577.34 ^d (1640.22)
2	Chitradurga	Linear	1.0	0.6566	0.8542	-5476.97 (5190.13)	2445.24 (082.59)	0.3434 ^a (0.6197)	0.8911 (0.8720)	29.71 ^b (14.068)	782.01 (1897.82)	0.6791 (0.5232)	272.23 (411.69)
3	Bijapur	Log-Linear	0.5	0.9408	0.9160	0.5428 (0.6324)	0.331 (0.0481)	0.0592 (0.01211)	-0.0723 (0.0727)	0.2087 ^d (0.1364)	0.344 (0.0369)	0.7175 ^a (0.0921)	0.0688 (0.1242)
4	State	Linear	1.0	0.6874	0.9822	-83240.99 ^b (39818.50)	4611.33 ^a (13472.69)	0.3126 ^c (0.1833)	0.2117 (1.340)	56.7 ^b (26.664)	4406.036 (3817.026)	2.3476 ^a (0.4674)	4109.50 ^a (680.824)

Note: Figures in parentheses indicate the standard errors of regression coefficients

- a = significant at 1 per cent level
- b = significant at 5 per cent level
- c = significant at 10 per cent level
- d = significant at 20 per cent level

Table 4.3 Estimated short-run and long-run price elasticities of hectareage of Onion

District	Short-run price elasticity	Long-run price elasticity
Dharwad	0.0185	0.0192
Chitradurga	0.0593	0.0903
Bijapur	0.331	0.351
State	0.0112	0.0162

Table 4.4 Estimated short-run non-price elasticities of hectareage of Onion

District	Current year desired yield (Y^*_t)	Average pre-sowing months rainfall (W^*_t)	Relative return risk factor (R^*_t)	Irrigation factor (I^*_t)	Trend variable (T^*_t)
Dharwad	0.2652	0.6405	-0.0352	-0.1505	1.1843
Chitradurga	0.302	1.3286	0.0462	0.4312	0.3792
Bijapur	- 0.0723	0.2087	0.344	0.7175	0.0688
State	0.1292	0.8199	0.0998	0.8022	0.4883

The regression coefficient of lagged relative prices was positive for all the selected districts including state as a whole. While the significant influence was found only in the case of Dharwad district and the State as a whole.

The short-run price elasticities of onion hectareage (Table 4.3) were found to be positive in all the cases and ranged from 0.331 (Bijapur) to 0.0593 (Chitradurga). As the in case of short-run price elasticities, the long-run price elasticities of hectareage of onion were turned out to be positive wherever price had positive impact on hectareage. However, the magnitudes of the values of both the short and long-run price elasticities were minimal and inelastic in nature except Chitradurga district where the magnitude was higher.

Interestingly, the regression coefficients for lagged hectareage variable were observed to be positive in all the cases. They were significant at different levels except in the case of Dharwad and Bijapur districts.

Similarly, the regression coefficients for the yield factor were positive in all the cases except in Bijapur district where it was found to be negative. The statistically significant value of the expected yield was observed only in the case of Dharwad district.

The short-run elasticity with respect to expected yield (Table 4.4) ranged between 0.302 (Chitradurga) to 0.2652 (Dharwad) in the case of positive relation and was negative (-0.0723) for Bijapur district.

The impact of pre-sowing period rainfall on hectareage of onion was observed to be positive and highly significant in the cases except for Bijapur where it was positive and feebly significant.

In the case of direct relationship between pre-sowing rainfall and hectareage were estimated to be 0.2087 and 1.3286 respectively for Bijapur and Chitradurga districts.

The relative return risk factor coefficients were negative in Dharwad district and the short-run elasticities was found to be -0.0352. In rest of the cases, i.e, Chitradurga, Bijapur and the state as a whole the impact of relative return risk factor was found to be positive and the short-run elasticities varied from 0.344 (Bijapur) to 0.0998 (State). But, the relationship between hectareage and the risk factor was non-significant in all the cases (Table 4.4).

The regression coefficients for the irrigation variable tended to show a positive impact on hectareage of onion in all the cases. While, there was negative impact in the case of Dharwad. However, the effect of irrigation was highly significant only in Bijapur district and the State as a whole.

The short-run elasticities with respect to irrigation variable was found to be -0.1505 for Dharwad district and varied from 0.4312 (Chitradurga) to 0.8022 (State) in all other cases.

The trend variable showed a positive impact on hectareage in all the cases. The significant impact was however, observed only in Dharwad and at the State level.

The short-run elasticities of trend variable was positive in all the cases and ranged between 0.3792 (Bijapur and Chitradurga districts) to 1.1843 (Dharwad) in the rest of the cases.

4.3 Yield response of onion

The estimated yield responses of onion for the three selected onion producing districts and the State as a whole are depicted in the Table 4.5. The short and long-run price elasticities and the short-run non-price elasticities of yield of onion are presented in Table 4.6 and 4.7 respectively.

The functional form of the yield response equations was found to be linear in all the cases due to goodness of fit. The values of R^2 , coefficients of multiple determination, had ranged from 0.7073 (State) to 0.7352 (Bijapur), which were significant at one per cent level. The value was low (0.4726) in the case of Chitradurga.

Table 4.5 Estimated yield response functions of Onion

Sl. No.	District	Functional form	Coefficient of expectation (β)	Coefficient of yield adjustment (α)	Coefficient of determination (R^2)	Constant	One year lagged relative price (P_{t-1})	One year lagged desired yield (Y^*_{t-1})	Rainfall deviation (W_{2^*t})	Relative return risk factor (R^*_{t-1})	Irrigation factor (I^*_{t-1})	Trend variable (T^*_{t-1})
1	Dharrwad	Linear	1.5	0.7227	0.7248	-3263.21 (3875.79)	-9644.1 (8195.60)	0.2773 ^a (0.6953)	9.5642 ^a (3.2921)	-1113.88 (1146.12)	-0.1659 (0.2310)	369.04 ^d (231.15)
2	Chitradurga	Linear	1.5	0.3112	0.4726	-7761.07 (60.18)	-2139.27 (3159.88)	-0.6889 ^d (0.6637)	10.3454 ^d (9.9163)	-1342.33 (1932.87)	-0.3561 (0.3878)	190.066 ^d (168.33)
3	Bijapur	Linear	1.0	0.7385	0.7352	11403.08 (10258.09)	-49.728 (3827.62)	0.2615 ^a (0.3434)	25.033 ^b (10.384)	-325.82 (659.60)	-1.5842 ^b (0.8998)	512.41 ^d (399.63)
4	State	Linear	1.5	0.1733	0.7073	1456.45 (2024.99)	-16722.29 ^a (6039.44)	0.8267 ^b (0.5020)	7.7767 (8.8270)	1578.74 ^d (1350.93)	-0.2861 ^a (0.1076)	526.857 ^a (121.29)

Note: Figures in parentheses indicate the standard errors of regression coefficients

- a = significant at 1 per cent level
- b = significant at 5 per cent level
- c = significant at 10 per cent level
- d = significant at 20 per cent level

Table 4.6 Estimated short-run and long-run price elasticities of yield of Onion

District	Short-run price elasticity	Long-run price elasticity
Dharwad	-0.0838	- 0.115
Chitradurga	-0.0827	- 0.265
Bijapur	-0.0313	- 0.0423
State	-0.1261	- 0.727

Table 4.7 Estimated short-run non-price elasticities of yield of Onion

District	Rainfall deviation ($W_2^*{}_t$)	Relative return risk factor ($R^*{}_t$)	Irrigation factor ($I^*{}_t$)	Trend variable ($T^*{}_t$)
Dharwad	0.5977	- 0.0734	- 0.4811	2.315
Chitradurga	0.0641	- 0.7525	- 0.2348	3.2058
Bijapur	0.2366	- 0.1370	- 0.9234	3.2061
State	0.2649	0.0634	- 0.1312	- 0.4989

The best value for the coefficient of expectation (β) was found to be 1.5 for all the districts and the State as a whole except in Bijapur district where it was found to be best at the value of β equals 1.0. The coefficient of yield adjustment (α) ranged between 0.1733 (State) to 0.7385 (Bijapur).

The regression coefficients of lagged relative prices were found to be negative in all the cases but statistically significant for the state as a whole only (Table 4.5).

The short-run price elasticities (Table 4.6) with respect to lagged relative price were found to be negative in all the cases and ranged between -0.0313 (Bijapur) to -0.0838 (Dharwad). At the State level the short-run price elasticity of yield of onion was -0.1261. The long-run elasticities with respect to the same variables ranged between -0.115 (Dharwad) to -0.727 (State) for all the cases. Compared to the short-run price elasticities the magnitudes of the long-run price elasticities barring Bijapur district were lower. The long-run price elasticities of yield of onion were lower relative to their corresponding hectareage responsiveness except in Bijapur district where the long-run price elasticities of yield of onion were higher than that of hectareage.

Interestingly, the lagged yield variable had a positive influence on the current yield of onion in all the cases except in case of Chitradurga district where it was found to be negative and non-significant. However, the positive impact of the lagged yield variable was non-significant in all the cases.

The coefficients of the absolute deviation of actual rainfall from the normal rainfall possessed positive sign in all the cases. However, the impact of rainfall deviation factor on the yield of onion was statistically significant for all the cases except for the state as a whole.

The regression coefficients of the risk factor turned out to be negative in three out of the four cases, in accordance with the expectation, while it was found to be positive in the case of the state as a whole. But, only the state as a whole was found to be feebly significant.

The short-run elasticities of the risk factor was in the range of -0.0734 (Dharwad) to 0.0634 (State).

The irrigation factor had a negative impact on yield of onion with respect to irrigation were -0.1312 (state) to -0.9234 (Bijapur). While, the significance was observed only in the case of Bijapur and the State as a whole.

The trend variable was observed to have a positive impact on yield levels for all the districts and the State as a whole and was significant at different levels.

The elasticities of yield with respect to the trend variable (Table 4.7) were positive in the range of 0.4989 (State) to 3.2061 (Bijapur).

4.4 Production response of onion

The estimated production response functions of onion for the study districts along with the aggregate production response function of the State as a whole have been depicted in the Table 4.8. The district wise estimated short and long-run price and non-price elasticities of onion production are presented in Table 4.9 and 4.10 respectively.

The functions selected for Dharwad, Bijapur and the State as a whole were linear. While, the Chitradurga district was found to be log-linear. The explanatory variables accounted for more than 90 per cent of the variation in the production of onion in all the districts and at State level barring Chitradurga district where the value of the coefficient of multiple determination (R^2) was 0.85. All the R^2 values were statistically significant at one per cent level.

The best value for the price expectation coefficient (β) was observed to be 1.0 in all the cases. The values for the coefficient of production adjustment (λ) ranged between 0.8685 (State) to 0.9662 (Bijapur).

The one year lagged relative price factor was found to have direct relationship with onion production in Bijapur and Chitradurga districts But, this relation was inverse in the case

Table 4.8 Estimated production response functions of Onion

Sl. No.	District	Functional form	Coefficient of expectation (β)	Coefficient of production adjustment (λ)	Coefficient of determination (R^2)	Constant	One year lagged relative price (P_{t-1})	One year lagged desired production (Q^*_{t-1})	Rainfall deviation (W_2^*t)	Relative return risk factor (R^*t)	Current year desired yield (Y^*t)	Trend variable (T^*t)
1	Dharrwad	Linear	1.0	0.9614	0.9016	-28611.81 (44092.75)	-231499.38 ^c (139261.3)	-0.0386 (0.3170)	24.085 (49.38)	25538.87 ^b (11384.52)	15423 ^a (3.522)	7174.32 (7334.26)
2	Chitradurga	Loglinear	1.0	0.9410	0.8552	0.9987 (0.9686)	0.0589 (0.0908)	0.05877 (0.0207)	-0.0102 (0.0478)	-0.0830 ^d (0.0892)	0.8848 ^a (0.1530)	0.0186 (0.2232)
3	Bijapur	Linear	1.0	0.9662	0.9028	42702.81 (24689.05)	99211.15 (145499.29)	-0.03375 ^a (0.1345)	-119.07 (39.05)	-1621.22 (2918.21)	8.695 ^a (0.996)	2814.007 ^d (1946.90)
4	State	Linear	1.0	0.8685	0.9618	-1101316.20 (386936.1)	-668710.53 ^b (291140.9)	-0.1315 ^b (0.5761)	668.28 (314.32)	-5429.61 (58506.37)	61.48 ^a (10.12)	42228.75 ^a (11529.65)

Note: Figures in parentheses indicate the standard errors of regression coefficients

- a = significant at 1 per cent level
- b = significant at 5 per cent level
- c = significant at 10 per cent level
- d = significant at 20 per cent level

Table 4.9 Estimated short-run and long-run price elasticities of production of Onion

District	Short-run price elasticity	Long-run price elasticity
Dharwad	- 0.0047	- 0.0048
Chitradurga	0.0589	0.0625
Bijapur	0.0040	0.0041
State	- 0.0017	- 0.0019

Table 4.10 Estimated short-run non-price elasticities of production of Onion

District	Rainfall deviation ($W_2^*_t$)	Relative return risk factor (R^*_t)	Current year desired yield (Y^*_t)	Trend variable (T^*_t)
Dharwad	0.1282	0.1248	0.0138	1.6598
Chitradurga	- 0.0102	- 0.0830	0.8848	0.0186
Bijapur	- 0.0912	- 0.0511	0.1261	0.3236
State	0.0593	- 0.1830	1.0096	0.2477

of Dharwad district and the State as a whole as against the expectation. However, the significant influence exerted by the price factor was observed, however, in case of Dharwad and the State as a whole only.

The short-run price elasticities of production (Table 4.9) were positive in Chitradurga and Bijapur districts. While, it was negative in Dharwad district and the State as a whole. The positive values ranged between 0.0040 (Bijapur) to 0.0589 (Chitradurga) . while the negative values ranged between -0.0017 (State) to -0.0047 (Dharwad). The long-run elasticities with respect to the same variables ranged between -0.0019 (State) to 0.0625 (Chitradurga). Compared to the short-run price elasticities the magnitudes of the long-run price elasticities were feebly higher.

The regression coefficient of the lagged production variable was negative in all the cases except, Chitradurga district which was positive. However, the significant influence of the variable was not observed in any of the cases.

The parameters of the rainfall deviation had an anticipated negative sign for Bijapur and Chitradurga districts. But, in Dharwad district and for the State as a whole the impact of the same variable was positive. However, the effect of this variable emerged to be significant only in the case of Bijapur district and the State as a whole.

The regression coefficients of the risk factor turned out to be negative in three cases out of the four cases, in accordance with the expectation, while they were positive in the case of Dharwad district and found to be significant. Negative short-run elasticities of risk variable were ranging from -0.0511 (Bijapur) to -0.1830 (State). The positive impact for the same variable were estimated to be 0.1248 (Dharwad).

The short-run elasticities of production with respect to expected yield were positive in all the cases and highly significant.. The values of the same variables were 0.0138, 0.8848, 0.1261 and 1.0096 for Dharwad, Chitradurga and Bijapur and the State as a whole respectively. The elasticities were positive with a magnitude from 0.8848 (Chitradurga) to 1.0096 (State).

The time trend variable had a positive effect on production in all the cases. However, the significant influence was observed only in the case of Bijapur and the State as a whole.

The short-run elasticities of production with respect to the trend variable were positive in all the cases with the value ranging from 0.0186 (Chitradurga) to a higher magnitude of 1.6598 in Dharwad district.

5. DISCUSSION

The results of the study presented in the previous chapter are analyzed, interpreted and discussed in this chapter under the following heads.

5.1 Growth in area, production and productivity of Onion

5.2 Hectareage response of onion

5.3 Yield response of onion

5.4 Production response of onion

5.1 Growth in area, production and productivity of onion

5.1.1 Dharwad district

The positive growth rate in the case of area devoted to onion in Dharwad district was highly significant. This could be explained by the high prices secured by the farmers. The area under onion significantly increased over the years in the district. The growth rate in productivity was positive and highly significant. Its magnitude was also negligible. This indicated that the productivity of onion remained almost the same over the years. The significant positive growth rate in the production of onion in the district could be explained by the effect of positive growth in the area under cultivation of the crop.

5.1.2 Chitradurga district

The growth in area under onion was positive and highly significant in Chitradurga district. This small increase in the area under onion was mainly attributed due to decline in the area under its competing crop.

The growth rate in productivity was also positive but non-significant. This small increase in the yield per hectare of onion in Chitradurga district might be attributed due to improvement in technology and good management of the fields.

A small increasing trend of production of onion in Chitradurga district could be explained by the both area and productivity of the crop over the years. However, it was mainly due to the increase in the area under the crop, being the increase in the yield very small.

5.1.3 Bijapur district

Bijapur district registered a significant positive growth in area under onion. This could be explained by the high prices secured by the farmers, which made the farmers to increase the area under onion.

The increasing trend of production of onion in Bijapur could be explained by the increase in both area and productivity of the crop.

The productivity of the onion in the district showed a significant positive growth rate. This might be attributed due to utilization of proper combination of inputs and good management of the fields.

5.1.4 Karnataka state

The Karnataka state as a whole registered a significant positive growth rate in area under onion. This was mainly a result of a positive growth rate in area under the crop at the State level, as the major onion growing districts which have a share of about 50 per cent of the total area under onion in the state.

The productivity of onion in the State as a whole showed a positive and increasing trend but, was of lower magnitude. Again this significant increase in the yield per hectare of onion was attributed due to the improvement in technology in the production of onion.

The total production of onion at the State level registered a significant positive growth rate. This was explained mainly by the effect of positive growth in area under the onion crop over the years in the State. The positive growth in area under the crop was sufficient enough to increase the increasing trend of yield per hectare of onion.

5.2 Hectareage response of onion

The explanatory variables included in the hectareage response model of the present study were: the lagged relative price, lagged onion hectareage, expected onion yield, pre-sowing average rainfall, relative return risk, total irrigated area of onion and the time trend.

All the four regression equations attempted for the hectareage response of onion (Table 4.2) were found to be statistically significant at one per cent level when judged by the criterion of 'F' test for multiple determination (R^2). The magnitudes of the coefficient of R^2 were considerably high in the range of 0.7352 (Bijapur) to 0.7248 (State) in all the cases. This clearly indicated that the major variation in hectareage of onion has been explained with the variables included in the fitted area response models.

5.2.1 Lagged Relative Price (P_{t-1})

The estimates of the coefficients of the lagged relative price showed the positive response of price factor in all the cases. Of the four positive estimates observed, State as a whole and Dharwad was statistically significant at 1 and 5 per cent respectively. The significant parameters of the price factor in the case of State as a whole and Dharwad clearly implied a normal positive relationship between the variations in the hectareage and the price factor of onion in the State. This means a rupee increase in the relative price of onion would induce the farmers in the State to increase the onion area by 4611.33 hectare during the current year and 1060.90 hectare in Dharwad district. The phenomenon was indicative of the price consciousness on the part of the farmers and reflected their area allocation behaviour in accordance with the economic rationale. That is, farmers would allocate their limited land resources to that crop enterprise towards which the relative price movements tend to be favourable. This was however, quite logical and rational as the allocation of land to a better-priced crop would fetch more revenue to farmers.

The price factor for Bijapur and Chitradurga districts assumed no statistical significance and hence was of no real consequence in the variations in onion hectareage in these districts.

Table 4.4 presents the estimates of short and long-run price elasticities of onion hectareage. The short-run elasticities in the case of response functions ranged from 0.331 (Bijapur) to 0.0593 (Chitradurga), The long-run price elasticities varied from 0.351 (Bijapur) to 0.0903 (Chitradurga) respectively. Thus, the table revealed not much wide differences between the short and long-run elasticities. This indicated that the farmers didn't take more time in adjusting the hectareage under onion in accordance with the changes in its relative price.

The estimated price elasticities of hectareage of onion generally showed the inelastic nature of hectareage of onion crop in the State both in short and long-run. The same trend was observed in the selected districts. This is however, may be because of the increase in the prices of onion were not to the extent that induced farmers to allocate more area to this crop and absence of adequate support and remunerative price policies.

5.2.2 Area Adjustment Coefficient (γ)

The values of coefficient of area adjustment (γ) ranged from 0.6566 in the case of Chitradurga district to 0.9662 in the case of Dharwad district. The relatively high magnitude of the coefficient in respect of Dharwad (0.9662) and Chitradurga (0.6566) were indicative of relatively fewer and less rigid constraints in adjusting the area in accordance with the price changes in these districts.

Interestingly, the coefficients of one year lagged hectareage of onion (A^*_{t-1}) were positive and statistically significant at different levels in chitradurga and State as a whole barring Dharwad and Bijapur district where the impact of this variable was positive but not

significant. The statistically significant influence of lagged hectareage indicated that the one year lagged area of onion have influenced the farmers' decision regarding area allocation to the crop in all the selected major onion growing districts (except Bijapur) and at the State level.

This was corroborated with the results of Lal (1987) for sugarcane in Uttar Pradesh, Tripathi and Gowda (1993) for groundnut in Orissa, Patel and Singh (1994) for bajra in Gujarat, Bhowmick and Goswami (1998) for winter rice, rape and mustard, potato crops in some districts of Assam wherein lagged area emerged as a significant variable affecting the current area under the crops.

5.2.3 Expected Yield (Y^*_t)

The coefficients of the expected yield variable had positive response for all the districts and Karnataka State except in Bijapur district where the expected yield variable had an inverse relation with area of onion. However, the coefficients were statistically not significant in any of the selected district and also state as a whole. The fact that the coefficients were not significant for the rest of the cases implied that this variable had no definite consequence on the variation in the area under onion in these cases.

The studies of Rajkrishna (1963), Parikh (1972), Basavaraja (1982), Dhindsa and Anju Sharma (1997) indicated significant influence of yields of different crops on their hectareage.

The estimated short-run elasticity of the yield variable ranged from -0.0723 (Bijapur) to 0.2652 (Dharwad). The relatively large values of short-run elasticities in Dharwad district and the State as a whole implied that the farmers of Dharwad and at the State level responded more to the variation in yields when compared to those in other districts of the study area.

5.2.4 Pre-sowing Rainfall ($W_1^*_t$)

The pre sowing period rainfall average was employed as a proxy for capturing the weather influence on the hectareage allocation decisions. The effect of this variable was found to be positive and significant in all the districts as well as state at 5 and 20 per cent level respectively. The statistically significant relation of this variable with area of onion implied that the farmers' area allocation decision pertaining to onion depended upon the amount of rainfall received during the pre-sowing period whether it would be excess or insufficient. In this particular case however, onion crop being relatively requiring more water during germination and hence area allocation to onion crop was purely dependent on rainfall. Mahajanashetti *et al.* (1990) for jowar crop in Belgaum, Bellary, Mysore and Hassan districts of Karnataka State also found the same result.

5.2.5 Relative Returns Risk (R^*_t)

The expected relative return risk variable which included both price and yield risks was incorporated in the area response model to measure the impact of risk over the variations in the hectareage under onion in Karnataka State.

The estimated coefficients of this variable turned out to be positive in two districts (Bijapur, Chitradurga) and in the case of State as a whole, where as in case of Dharwad it was negative. . But the statistical significance of the variable was not observed in any of the cases. The farmers of Bijapur, Chitradurga districts tended to take risk. On the other hand, the coefficients were negative in Dharwad district but were not significant. The negative coefficient of the relative return risk variable implied that the farmers of Dharwad district appeared to be risk-averters in their onion hectareage allocation decision. Further it also indicated the progressive outlook of the farmers towards price movements of alternative crops in allocating area under a particular crop. Maji *et al.* (1971), Basavaraja (1982), Dixit (1982), Mahajanashetti (1987) and Deshpande (1994) also reported similar mixed results for this variable in their studies.

The short-run elasticities of risk factor varied form -0.0462 (Chitradurga) to 0.0998 (State). The magnitude of the short-run elasticities in the all the cases were not significant.

The magnitude and the consequential changes in hectareage of onion due to the risk factor were low and of minor nature in other districts and State as a whole.

5.2.6 Irrigation (I^*_t)

The irrigation variable had a positive relationship with the hectareage of onion in all the districts and at the State level except in Dharwad district.

The statistically significant estimated coefficients of this variable, however, were observed in Bijapur district and at the State level. This positive and significant impact of irrigation on area of onion implied that improvement in irrigation facilities in these districts and State at large induced farmers to put more area of land under onion cultivation.

The relatively higher short-run elasticities of onion area in State and Chitradurga district indicated that the farmers of this area were found to respond more favorably towards the expansion of irrigation facilities than the farmers of other districts with regard to extension of onion cultivation. At the State level the magnitude of the short-run elasticity of onion area was 0.8022 which indicated the response of onion farmers in Karnataka State were moderate and positive to the provision of irrigation facilities.

In Dharwad district however, the irrigation though statistically non-significant had negative impact on area of onion implying the farmers of this district tended to shift onion area to some other crops where they can get more return as the irrigation facilities expand.

5.2.7 Time Trend (T^*_t)

The trend variable which represented the left out variables including technological changes was incorporated into the model as a "catch-all" variable. The impact of this variable was observed to be positive in the entire selected districts. The statistically significant effect of the trend variable was found in Dharwad and state at the State level. The positive impact of this variable indicated that as the time passed, the hectareage allocation to onion crop showed increasing trend.

The short-run elasticities showed positive response of hectareage to trend in all the cases and the Karnataka State as a whole. The elasticities with respect to this variable were generally found to be inelastic. This implied that as the time passed changes in technology and other factors which were not included in the model didn't cause much variation in area of onion crop in the State.

5.3 Yield response of onion

The estimated yield response of onion in the selected districts and Karnataka State are presented in Table 4.4.

The determining variables included in the yield response model were: the lagged relative price, the one year lagged expected yield of onion, the absolute deviation of growing period's rainfall from the normal rainfall, relative return risk, irrigation and time trend.

The overall significance of the response functions was very at one per cent level in all the study districts and at the State level as indicated by the 'F' test for R^2 . The R^2 values ranged from 0.4726 (chitradurga) to 0.7352 (Bijapur). The model explained above 70 per cent of the variation in the yields of onion for Karnataka State as a whole.

5.3.1 Lagged Relative Price (P_{t-1})

The results presented in Table 4.4 revealed that the previous year's relative price of onion influenced significantly the productivity of onion in all the cases. However, the relationship between the price factor and the yield of onion was inverse in all the cases implying that as the relative price of onion decreased the farmers in Dharwad, Chitradurga and Bijapur districts tended to reduce the yield of the crop. The negative relationship However, statistically non- significant in all the selected districts. Dharwad, Bijapur and Chitradurga districts being the predominant producers of onion in the State, the farmers there

probably adjusted the output of onion largely by adjusting the hectareage under onion rather than by increasing yield levels of onion.

At the State level this factor showed a significant inverse relationship with yield of onion. One rupee increase in the price of onion in the previous year would decrease the yield by -16722 kg (per hectare) in the current year. This phenomenon was supported by the result indicated in Table 4.1, that farmers tended to respond to changes in price of onion by making an adjustment to area under the crop rather than by manipulating the yield. Such a negative and significant impact of the price factor was also reported in the previous studies, Mahajanashetti (1987), Murthy *et al.* (1992) and Deshpande (1994).

The short-run price elasticities of yield varied from - 0.0313(Bijapur) to - 0.1261 (state) for the negative functions. The corresponding long-run elasticities varied from -0.115 (Dharwad) to -0.727 (State).

5.3.2 Yield Adjustment Coefficient (α)

The yield adjustment coefficient varied from 0.1733 (State) to 0.7385 (Bijapur) indicating highly varying degrees of rigidities in the process of adjusting the current yield to the desired level. The high magnitude of the adjustment coefficient in respect of Bijapur district indicated that there existed relatively less rigid institutional and technological barriers against the yield adjustment with the changes in prices. On the other hand the smaller values in the case of other districts and the State at large signified high degree of constraints in the adjustment process. The adjustment of yield to the desired level required fairly long-period of time.

5.3.3 Rainfall Deviation (W_2^*t)

Out of the four cases Dharwad, Chitradurga, and Bijapur evidenced positive impact of the rainfall deviation, which was in conformity with the hypothesis that deviation of rainfall from normal (either positive or negative) affects the yield of onion. It is interesting to note that the statistical significance influence was found to be at different levels of this variable. The positive and significant relationship indicated that there existed marginal difference between the actual and the normal rainfall, which resulted in increase of the onion yield. This finding was strengthened by similar results of Parmeshwar (1993) and Nagaraj (1994).

The short-run elasticities of the rainfall deviation (Table 4.6) were very high and tended to be perfectly inelastic indicating one millimeter change in rainfall from normal caused almost no changes in the yield.

5.3.4 Relative Return Risk (R^*t)

The impact of risk on the yield level of onion was not significant in the case of the State as a whole, though the regression coefficient was positive. For the rest of the cases the coefficient emerged to be negative. This implied a perverse relationship of risk factor with the yield levels of onion. This indicated that the farmers in these districts did not seem to assume risk in adopting modern production technology of onion if made available and there by increasing its productivity.

The short-run elasticities of yield of onion with changes in relative return risk varied from -0.0734 (Dharwad) to 0.0634 (State). (Table 4.7) The magnitude of elasticities was generally lower in nature implying that the impact of this variable on the yield of onion was not so strong.

5.3.5 Irrigation (I^*t)

A negative impact of irrigation on the yield of onion was observed in all the cases, but it had turned out to be significant (at one per cent level) in Bijapur district and the State as a whole. The negative effect of irrigation in these districts might have come from improper management of irrigation like excess irrigation of the crop which might have caused water logging and salinity problems which in turn caused reduction in yield.

Similar results were obtained by Mahajanshetti (1987) in his study on supply response of jowar in Karnataka, wherein the irrigation coefficient of yield turned out to be significantly negative in all the selected districts and the State as a whole.

The short-run elasticities of yield were very low in all the cases and they were highly inelastic.

5.3.6 Time Trend (T^*_t)

The time trend variable had positive relationship with the yield of onion in the selected major onion growing districts. All the positive coefficients of this variable were statistically significant indicating that the onion producers in these districts tended to increase the yield of onion by making use of advanced technologies over time.

The estimated short-run elasticities of yield of onion with respect to the time trend variable were very high and inelastic in all the cases except for the state as a whole. This has implied that changes in technologies and other factors, which were not included in the model, have caused not much change in the yield of onion in the short-run.

5.4 Production response of onion

All the four estimated production response functions were highly significant at one per cent probability level as testified by the 'F' test for R^2 (Table 4.8). The values of the coefficient of multiple determination were above 0.90 except in chitradurga district where it was 0.8552. On the whole, 96.18 per cent of the variation in onion production in Karnataka State was explained by the model.

5.4.1 Lagged Relative Price (P_{t-1})

The results of the analysis of production response of onion (Table 4.8) showed that the lagged relative price had positive bearing on the production of onion in Bijapur, and Chitradurga districts. However a feebly significant impact of this variable was found only in Dharwad and at the state level. The explanation of this phenomenon could be that though there existed mild negative impact of price on the hectareage this might have not been more than offset of the strong positive impact on the productivity, as a result the production responded positively. It further implied that the farmers of Bijapur and Chitradurga tended to adopt yield increasing and land saving technologies in their production process. A totally opposite phenomenon was observed in Dharwad district and the State as a whole where, the increase in yield was not significant to offset the reduction in hectareage of onion and consequently reduction in the total production of onion occurred.

In Chitradurga district none of the responses (area, yield and production) emerged to be significant with respect to one year lagged price, while in Dharwad, Bijapur and the State as a whole the yield response showed highly significant impact but was not to that extent which could have brought significant influence on production.

At the State level, it was interesting enough to note that the significant negative impact of price factor on hectareage was totally offset by equally significant negative impact of this factor on yield, which has resulted in negative and significant influence of price on production of onion.

It could be noted from Table 4.9 that the price elasticities of production of onion which were less in magnitude and inelastic in nature in the short-run have jumped to as much as 0.0625 in the case of Chitradurga district and in case of other districts there was feeble increase. This implied that the farmers in these districts took a long time in adjusting the level of production of onion to changes in its prices.

5.4.2 Production Adjustment Coefficient (λ)

The relatively higher values of coefficients of production adjustment in all the cases suggested that the farmers in these districts and in the State in general were confronted with relatively few and less rigid technological and institutional constraints in the production of onion and there existed a scope for further increment of production of the crop. The low

values of the coefficients in other cases reflected rigid technological and institutional barriers faced by the farmers and thus relatively longer period was needed for the adjustment of the production level.

The estimated coefficients of the lagged production were positive and statistically significant in Chitradurga district indicating that the production of onion in the previous year directly influenced the production of the crop in the current year. At the State level and other districts this variable showed negative and highly significant influence on current year production of the crop.

5.4.3 Rainfall Deviation (W_2^*t)

As expected, the rainfall deviation had negative impact on production of onion in Chitradurga and Bijapur districts. On the contrary, this variable showed a positive relationship with production of onion in Dharwad district and for the state as a whole. However, it was interesting to note that it was only in the case of State as a whole that a positive and feebly significant impact of rainfall was observed. This positive and significant relationship indicated that there existed marginal difference between the actual and the normal rainfall, which resulted in increased production. Such positive impact of the rainfall deviation on production level was reported by Mahajanashetti (1987) in his study on supply response of jowar in Karnataka and Deshpande (1994) in his study on supply response of chilli in Karnataka.

The short-run elasticities of production of onion with respect to rainfall deviation were very small in their magnitude indicating that the variable did not bring considerable change in the production level of onion crop in the State. The phenomenon showed that there existed no much variation in actual and normal rainfall during the growing period of the crop in the short-run.

5.4.4 Relative Return Risk (R^*t)

In Dharwad district the relative return risk factor showed direct relationship with the production of onion. This indicated that onion producers in this district tended to take risk in their decision process of onion production. However, this relationship was significant only in the case of Dharwad and Chitradurga districts.

In Chitradurga, Bijapur districts in particular and the State as whole farmers preferred to avoid risk in taking up onion production. This indicated that the farmers in these districts did not seem to assume risk in adopting modern production technology of onion if made available and there by increasing its productivity. Interestingly, onion farmers in Dharwad responded negatively to risk in terms of both hectareage and yield. At the State level, however, the farmers' response to risk factor in both hectareage and yield was positive and significant at five per cent in the case of hectareage response, which has resulted in negative but non-significant relationship between this variable and production. This might have come due to aggregation problem. Basavaraja (1982), Mahajanashetti (1987) and Deshpande (1994) also reported similar mixed results of positive and negative impact of risk on production.

As in the case of rainfall deviation the estimated short-run elasticities of onion production with respect to relative return risk were low and inelastic in nature. This phenomenon indicated that, in the short-run, changes in price and yield risk caused not much difference in production of onion crop in the study area.

5.4.5 Expected Yield (Y^*t)

The production response of onion with respect to the expected yield variable revealed a very strong positive impact on production of onion in Chitradurga district. This confirmed the hypothesis of direct relationship between the expected yield and the level of onion production. About one per cent increase in the expected yield caused an increase of nearly 33 quintals of onion production in this district.

The relatively high positive values of elasticities of production with respect to expected yield of onion (Table 4.10) in Chitradurga (0.8848) and the State (1.0096) implied that an increase in the expected yield of onion by one per cent would induce the farmers to

increase their production of onion by more than 0.75 and 1.2 per cent in Chitradurga and the State as a whole respectively.

5.4.6 Time Trend (T^*_t)

The coefficient of the time trend variable showed a positive impact on production of onion in all the cases. The positive and significant relationship between this variable and production of onion signified that onion production in the districts increased over time. But, this impact was statistically significant only in the case of Bijapur and the state as whole. The negative impact of trend on production was also reported by Basavaraja (1982) for cotton in Belgaum district and Deshpande (1994) for chilli in Belgaum and Shimoga districts and the Karnataka State as a whole.

6. SUMMARY AND POLICY IMPLICATIONS

In order to meet the raising demand for food of an enormously growing population in a developing country like India, a high growth rate in agriculture is most important. Agriculture being the predominant sector of the country, the economic development of the country depends mainly on its agricultural development. The production decisions of farmers are dependent on various policies of the government. Price policy, among the others, is the most important one. In addition to price incentives, some non-price factors like rainfall, irrigation, risk and the like too have important effects on the production decisions of farmers. Hence, the role played by the government by way of price fixation, market operations and providing some other incentives must be based on the knowledge of how precisely the producers respond to prices and non-price factors. Therefore, the study of farmers' supply response to price and non-price incentives is of considerable importance for devising suitable policy and planning development programmes for the agricultural sector of any economy, particularly in India where agriculture is the most important sector in the national economy. Onion, one of the important food crops in Karnataka State, has been selected for the present study with a view of analyzing its supply response behaviour with the following specific objectives

6.1 Specific objectives

1. To document the growth in area, production and Productivity of onion in Karnataka
2. To evaluate the impact of relative price and selected non-price factors on the supply of onion in Karnataka State,
3. To analyse the short and long-run price elasticities of supply of onion in the State.
4. To suggest appropriate policy measures for improvement of onion production in Karnataka State.

6.2 Study area

Three major onion growing districts of Karnataka State namely, Bijapur, Chitradurga, and Dharwad were selected based upon the percentage of the average onion area in the district over a period to that in the State and the percentage of average onion production in the district over the same period to that in the State. The supply response of onion in these districts as well as for the State as a whole was studied.

6.3 Nature and source of data

The study completely based on secondary data. The district wise time series data from 1980 to 2005 pertaining to the area, production and productivity of onion will be collected from the Bureau of Economics and Statistics, Government of Karnataka, Bangalore. In addition the data on month wise rainfall and irrigated area under onion will be extracted of the state from the records maintained by the Bureau.

6.4 Techniques of analysis

The Nerlovian Price Expectation-cum-Area Adjustment Model was adopted to estimate the area, yield and production response functions both in linear and log-linear forms and compound growth rate was adopted to measure the trend in area, production and productivity of onion in state.

6.5 Main findings of the study

The results of area, yield and production response analysis are discussed independently in the preceding chapter. Accordingly, the main findings of the study are summarized in this chapter as follows.

Growth Analysis

In Dharwad district, high prices of onion prompted the farmers in the district to enhance the production of onion by bringing more area under its cultivation. Besides, the black cotton soils in the district being most suitable for cultivation of onion. The area under the crop and the production of the crop registered significant positive growth rates.

In Chitradurga district, the growth rate in area under onion was positive and highly significant in Chitradurga district. The increasing trend of production of onion in the district could be explained by the increase in both area and productivity of the crop over the years.

Bijapur district registered a significant positive growth in area under onion. This could be result of high prices secured by the farmers to increase the area under onion. The increase in productivity of onion in the district attributed due to utilization of proper combination of inputs and good management in the fields.

The Karnataka state as a whole registered a significant positive growth rate in area under onion, which is a result of increase in the area under onion in the major onion growing districts, which have a share of about 50 per cent of total area under onion in the State.

Hectareage response of onion

The hectareage response of onion growers estimation explained more than 68 per cent of the variation in hectareage of onion in the selected districts and the state as a whole.

The estimates of the coefficients of the lagged relative price showed the positive response of price factor in all the cases. Of the four positive estimates observed, State as a whole and Dharwad was statistically significant at 1 and 5 per cent respectively. The significant parameters of the price factor in the case of State as a whole and Dharwad clearly implied a normal positive relationship between the variations in the hectareage and the price factor of onion in the State. The phenomenon was indicative of the price consciousness on the part of the farmers and reflected their area allocation behaviour in accordance with the economic rationale. That is, farmers would allocate their limited land resources to that crop enterprise towards which the relative price movements tend to be favourable. This was however, quite logical and rational as the allocation of land to a better-priced crop would fetch more revenue to farmers..

The coefficients of the expected yield variable had positive response for all the districts and Karnataka State except in Bijapur district. Where, the expected yield variable had an inverse relation with area of onion. The positive and significant impact of pre-sowing rainfall was evidenced in all the cases. This implied that the farmers' area allocation decision pertaining to onion depended upon the amount of rainfall received during the pre-sowing period whether it would be excess or insufficient. The irrigation variable had a positive relationship with the hectareage of onion in all the districts and at the State level except in Dharwad district.

The farmers of Dharwad district appeared to avert risk while that of Chitradurga and Bijapur districts and the State as a whole tended to take risk. The impact of trend variable was observed to be positive in the entire selected districts. The statistically significant effect of the trend variable was found in Dharwad and state at the state level. The positive impact of this variable indicated that as the time passed, the hectareage allocation to onion crop showed increasing trend.

The Yield Response of Onion

The explanatory variables included in the yield response models were the relative price, one year lagged expected yield, rainfall deviation, relative return risk, irrigation and the time trend. The model explained the variation ranging from 70 per cent (State).

The parameter of the relative price variable was negative and significant in all the cases. The relationship between the price factor and the yield of onion was inverse in all the cases implying that as the relative price of onion increased the farmers in Dharwad, Chitradurga and Bijapur districts tended to reduce the yield of the crop. Dharwad, Bijapur and

Chitradurga districts being the predominant producers of onion in the State, the farmers there probably adjusted the output of onion largely by adjusting the hectareage under onion rather than by increasing yield levels of onion. which can be supported from Table 4.2 where the price factor though non-significant had a negative impact on hectareage of onion in this district.

The lagged yield variable had a positive influence on the current yield of onion in all the cases except in case of Chitradurga district where it was found to be negative and non-significant. However, the positive impact of the lagged yield variable was significant in all the cases. The estimated coefficients of rainfall deviation factor signified the existence of positive influence of this variable in the districts and the State as a whole. This indicated that there was considerable variation between actual rainfall and normal rainfall which could have caused strong impact on yield of onion. The negative sign attached to the risk factor implied the farmers' risk aversion behavior in using yield increasing technologies in Dharwad, Chitradurga and Bijapur districts While the farmers' in the State as a whole were found to take risk in their decision making process to increase yield.

A negative impact of irrigation on the yield of onion was observed in all the cases. The short-run elasticities of yield were very low in all the cases and they were highly inelastic. The negative coefficient of this variable in all the cases indicated the improper utilization of irrigation, which has resulted in reduction of yield.

The time trend variable had positive relationship with the yield of onion in the selected major onion growing districts and the State as a whole. The estimated short-run elasticities of yield of onion with respect to the time trend variable were very high and inelastic in all the cases. This has implied that changes in technologies and other factors, which were not included in the model, have caused not much change in the yield of onion in the short-run.

The Production Response of Onion

The impact of price and non-price factors on the production of onion was examined for Karnataka State as a whole and three major onion growing districts thereof. The model explained 85 per cent of variation in production in the case of Chitradurga district and more than 90 per cent of the variation in all the remaining cases.

A positive and significant impact of price factor on onion production was observed in Chitradurga and Bijapur districts in which farmers increased the production of onion with increased previous year's price while exactly opposite phenomenon was found in Dharwad district and at the State level. In all other cases the impact of this variable emerged to be non-significant. It could be noted that the price elasticities of production of onion which were less in magnitude and inelastic in nature The relatively higher values of coefficients of production adjustment in all the cases suggested that the farmers in these districts and in the State in general were confronted with relatively few and less rigid technological and institutional constraints in the production of onion and there existed a scope for further increment of production of the crop. The low values of the coefficients in other cases reflected rigid technological and institutional barriers faced by the farmers and thus relatively longer period was needed for the adjustment of the production level.

As expected, the rainfall deviation had negative impact on production of onion in all the districts except for the state as a whole. On the contrary, this variable showed a positive relationship with production of onion at the State level. This positive and significant relationship indicated that there existed marginal difference between the actual and the normal rainfall, which resulted in increased production.

In all cases the relative return risk factor showed negative relationship with the production of onion. This indicated that onion producers in all the selected districts and the State as a whole tended to avoid risk in taking up onion production.

The coefficient of the time trend variable showed a positive impact on production of onion in all the cases. The positive and significant relationship between this variable and production of onion signified that onion production in the districts increased over time.

6.6 Policy implications

The results obtained from the present study conducted with a view to analyse the hectareage, yield and production responses of onion in the three selected major onion growing districts and State as a whole could be of immense use in prescribing policy measures to promote the supply of onion.

The main policy implications include

1. The study revealed that, with an increase in the relative price of onion, farmers in Chitradurga and Bijapur districts tended to increase the production of the crop mainly by bringing more area under its cultivation. Hence, in order to further enhance the production of onion, the on-going price policy should be directed towards assuring appropriate remunerative prices to the onion producers of the State.
2. Increase in the irrigation facilities with proper management practices could prove vital in increasing onion productivity. This was evident from Chitradurga and Bijapur districts as well as State as a whole. Hence, educating the farmers on proper irrigation management would substantially improve the prospects of onion production.
3. Onion growers in Dharwad, Bijapur and Chitradurga districts were found to avoid risks in increasing the area under the crop or in increasing the yield of the crop or in both. The risk arising out of price and yield fluctuations could be arrested by providing crop insurance to onion growers.
4. The negative bearing of expected yield on onion output was evident in districts of Chitradurga and Bijapur. This might be due to the existence of technological and institutional rigidities, which have hindered the farmers from adjusting the production as per their expectation. Therefore, there is a need for research to find out the problems faced by the farmers in order to tackle them and increase onion production.

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* Original not seen

APPENDIX I

Derivation of Reduced Form of Area Response Equation

The set of relations determining area response presented in Chapter III as equations (3.1), (3.2) and (3.3) are reproduced below.

$$P_t^* - P_{t-1}^* = \beta (P_{t-1} - P_{t-1}^*) \dots \dots \dots (1)$$

$$A_t - A_{t-1} = \gamma (A_t^* - A_{t-1}) \dots \dots \dots (2)$$

$$A_t = a_0 + a_1 P_t^* + a_2 Y_t + a_3 W_{1t} + a_4 I_t + a_5 R_t + a_6 T_t + U_t \dots \dots \dots (3)$$

The desired equation (3) cannot be directly estimated as expressed above, since it contains unobservable variables, desired area (A_t^*) and expected price (P_t^*). The estimable reduced form can be derived by substituting equations (1) and (2) in (3) to express the equation in terms of observable variables as follows:

From equation (2),

$$\gamma A_t^* = A_t - A_{t-1} + \gamma A_{t-1}$$

$$\text{Then, } A_t^* = (A_t/\gamma) - (1-\gamma) A_{t-1}/\gamma \dots \dots \dots (4)$$

From equation (1),

$$P_t^* = \beta P_{t-1} + (1-\beta) P_{t-1}^* \dots \dots \dots (5)$$

Now substituting the values of A_t^* and P_t^* from equation (4) and (5) in (3),

$$(A_t/\gamma) - (1-\gamma) A_{t-1}/\gamma = a_0 + a_1 (\beta P_{t-1} + (1-\beta) P_{t-1}^*) + a_2 Y_t + a_3 W_{1t} + a_4 I_t + a_5 R_t + a_6 T_t + U_t$$

This can be rewritten as,

$$A_t - (1-\gamma) A_{t-1} = \gamma a_0 + \gamma \beta a_1 P_{t-1} + \gamma(1-\beta) a_1 P_{t-1}^* + \gamma a_2 Y_t + \gamma a_3 W_{1t} + \gamma a_4 I_t + \gamma a_5 R_t + \gamma a_6 T_t + \gamma U_t \dots \dots \dots$$

... (6)

Now from equation (3),

$$A_{t-1}^* = a_0 + a_1 P_{t-1}^* + a_2 Y_{t-1} + a_3 W_{1t-1} + a_4 I_{t-1} + a_5 R_{t-1} + a_6 T_{t-1} + U_{t-1}$$

Taking $a_1 P_{t-1}^*$ to left hand side,

$$a_1 P_{t-1}^* = A_{t-1}^* - a_0 - a_2 Y_{t-1} - a_3 W_{1t-1} - a_4 I_{t-1} - a_5 R_{t-1} - a_6 T_{t-1} - U_{t-1}$$

Substituting for A_{t-1}^* similar to A_t^* as in equation (4)

$$a_1 P_{t-1}^* = (A_{t-1}/\gamma) - (1-\gamma)A_{t-2}/\gamma - a_0 - a_2 Y_{t-1} - a_3 W_{1t-1} - a_4 I_{t-1} - a_5 R_{t-1} - a_6 T_{t-1} - U_{t-1} \dots \dots (7)$$

Substitution of right hand side from equation (7) for $a_1 P_{t-1}^*$ in equation (6) gives,

$$A_t - (1-\gamma)A_{t-1} = \gamma a_0 + \gamma \beta a_1 P_{t-1} + \gamma(1-\beta)[(A_{t-1}/\gamma) - (1-\gamma)A_{t-2}/\gamma - a_0 - a_2 Y_{t-1} - a_3 W_{1t-1} - a_4 I_{t-1} - a_5 R_{t-1} - a_6 T_{t-1} - U_{t-1}] + \gamma a_2 Y_t + \gamma a_3 W_{1t} + \gamma a_4 I_t + \gamma a_5 R_t + \gamma a_6 T_t + \gamma U_t$$

This can be written as,

$$A_t - (1-\beta)A_{t-1} = \gamma \beta a_0 + \gamma \beta a_1 P_{t-1} + (1-\beta) [A_{t-1} - (1-\beta)A_{t-2}] + \gamma a_2 [Y_t - (1-\beta) Y_{t-1}] + \gamma a_3 [W_{1t} - (1-\beta)W_{1t-1}] + \gamma a_4 [I_t - (1-\beta)I_{t-1}] + \gamma a_5 [R_t - (1-\beta) R_{t-1}] + \gamma a_6 [T_t - (1-\beta)T_{t-1}] + \gamma [U_t - (1-\beta)U_{t-1}]$$

This can be further reduced as,

$$A_t^* = b_0 + b_1 P_{t-1} + b_2 A_{t-1}^* + b_3 Y_t^* + b_4 W_{1t}^* + b_5 I_t^* + b_6 R_t^* + b_7 T_t^* + e_{1t}^* \dots \dots (8)$$

Where,

$$A^*_t = A_t - (1-\beta) A_{t-1},$$

$$A^*_{t-1} = A_{t-1} - (1-\beta) A_{t-2},$$

$$Y^*_t = Y_t - (1-\beta) Y_{t-1}, \text{ etc.}$$

The equation (8) is given as estimating linear equation (3.4) in Chapter III.

Analogously, the reduced form of the equations are derived for yield and production response equations.

SUPPLY RESPONSE OF ONION IN KARNATAKA—AN ECONOMETRIC ANALYSIS

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ABSTRACT

The supply response of onion in Karnataka was studied to evaluate the impact of relative price and selected non-price factors and to analyse the short and long-run price elasticities.

Three major onion growing districts of the state namely, Dharwad, Chitradurga and Bijapur were selected. The Nelovian price Expectation- cum- Area Adjustment model was adopted.

The results indicated that the significant parameters of the price factor in the case of State as a whole and Dharwad clearly implied a normal positive relationship between variations in the hectareage and the price factor of onion in the State. There was a wide differences between magnitudes of short and long-run price elasticities in all the selected districts. The estimated price elasticities of hectareage generally showed elastic nature of hectareage response of onion.

The previous year's relative price of onion influenced significantly the productivity of onion in all the cases. However, the relationship between the price factor and the yield of onion was inverse implies that as the relative price of onion decreased the farmers in Dharwad, Chitradurga and Bijapur districts tended to reduce the yield of the crop. The price elasticities of yield in the selected districts and at state level are low in magnitude and inelastic in nature.

A positive impact of price factor on onion production was observed in Bijapur and Chitradurga districts while exactly opposite phenomono was found in Dharwad and at the state level.the short-run elasticity of production of onion showed positive price response of farmers in Chitradurga and Bijapur districts.

The onion growing farmers of the state in general were more responsive to the price factor compared to non-price viz. irrigation and rainfall variables.

Hence the on-going measures should be directed towards assuring appropriate remunerative prices to the onion producers of the State so as to commercialize the crop.